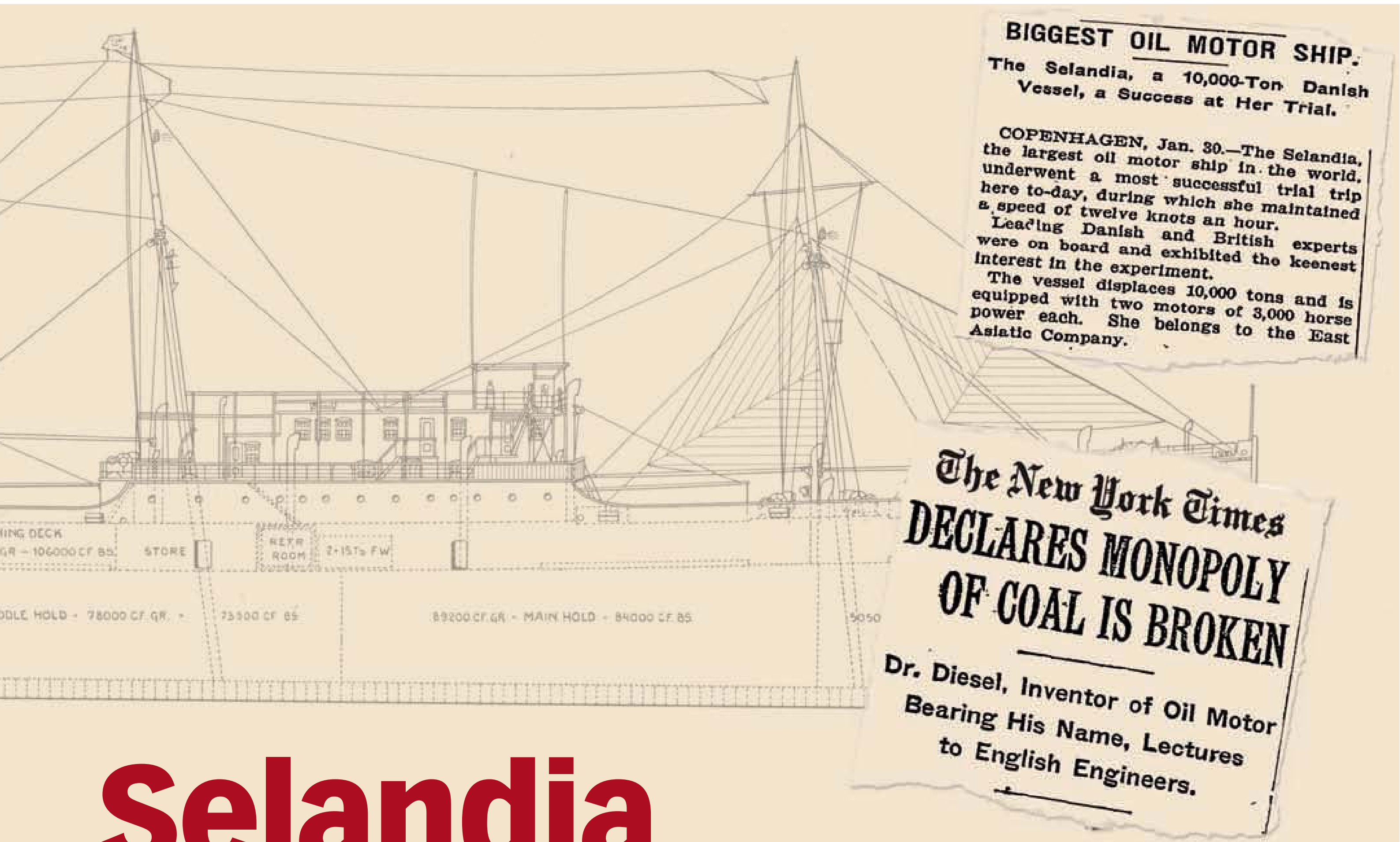

BIGGEST OIL MOTOR SHIP.

The Selandia, a 10,000-Ton Danish Vessel, a Success at Her Trial.

COPENHAGEN, Jan. 30.—The Selandia, the largest oil motor ship in the world, underwent a most successful trial trip here to-day, during which she maintained a speed of twelve knots an hour.

Leading Danish and British experts were on board and exhibited the keenest interest in the experiment.

The vessel displaces 10,000 tons and is equipped with two motors of 3,000 horse power each. She belongs to the East Asiatic Company.

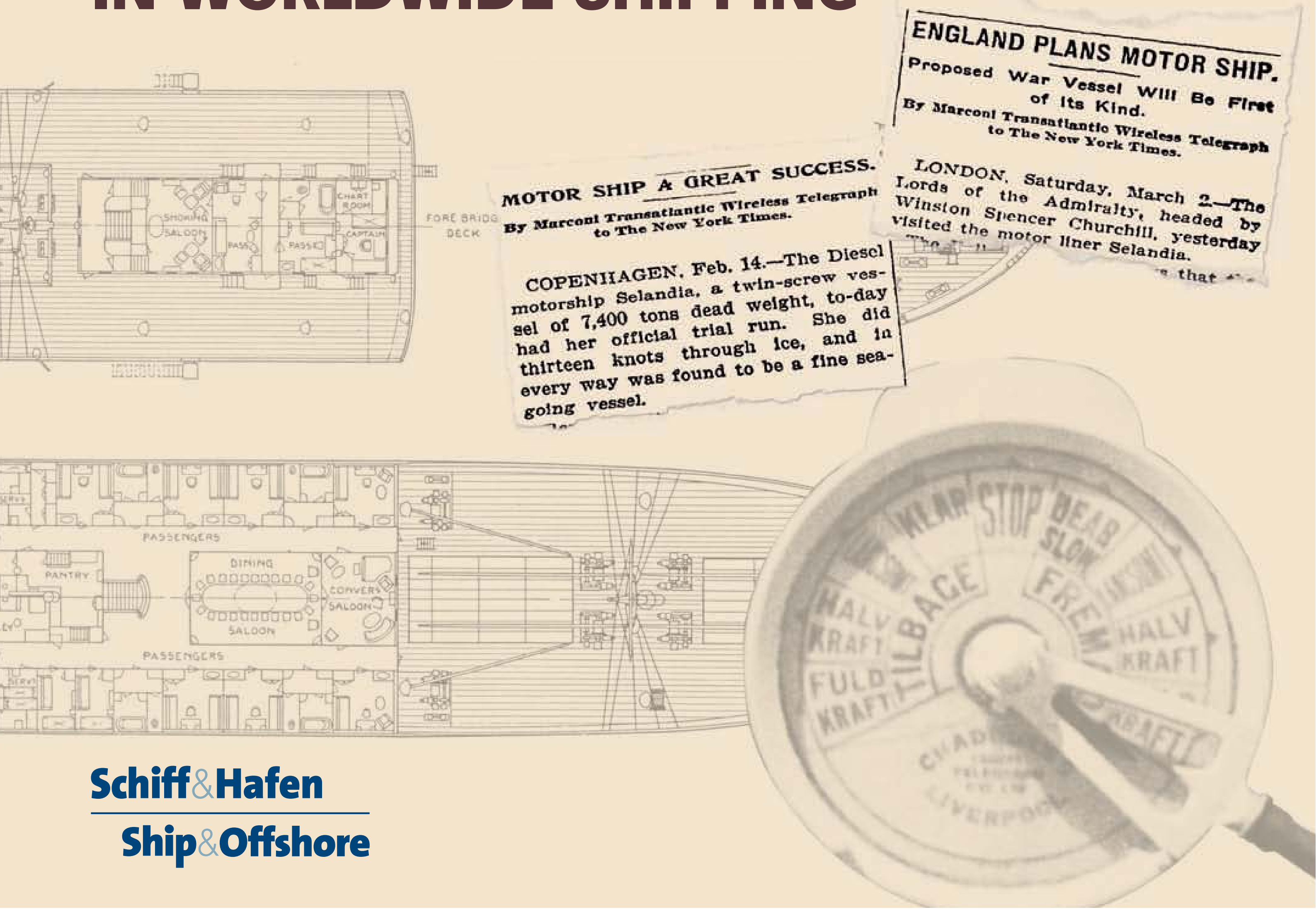
The New York Times

DECLARES MONOPOLY OF COAL IS BROKEN

Dr. Diesel, Inventor of Oil Motor Bearing His Name, Lectures to English Engineers.

Selandia

A CENTURY OF DIESEL PROPULSION IN WORLDWIDE SHIPPING


ENGLAND PLANS MOTOR SHIP.

Proposed War Vessel Will Be First of Its Kind.

By Marconi Transatlantic Wireless Telegraph to The New York Times.

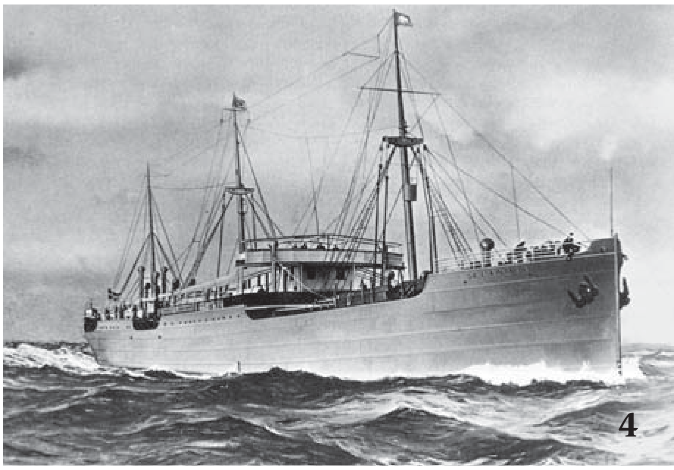
LONDON, Saturday, March 2.—The Lords of the Admiralty, headed by Winston Spencer Churchill, yesterday visited the motor liner Selandia.

MOTOR SHIP A GREAT SUCCESS.

By Marconi Transatlantic Wireless Telegraph to The New York Times.

COPENHAGEN, Feb. 14.—The Diesel motorship Selandia, a twin-screw vessel of 7,400 tons dead weight, to-day had her official trial run. She did thirteen knots through ice, and in every way was found to be a fine seagoing vessel.

Schiff&Hafen
Ship&Offshore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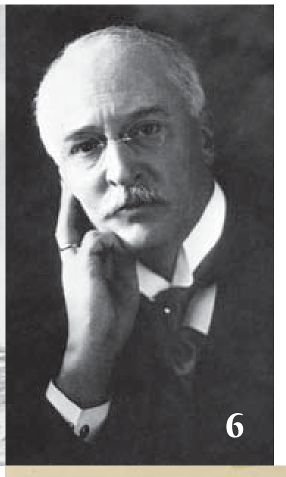
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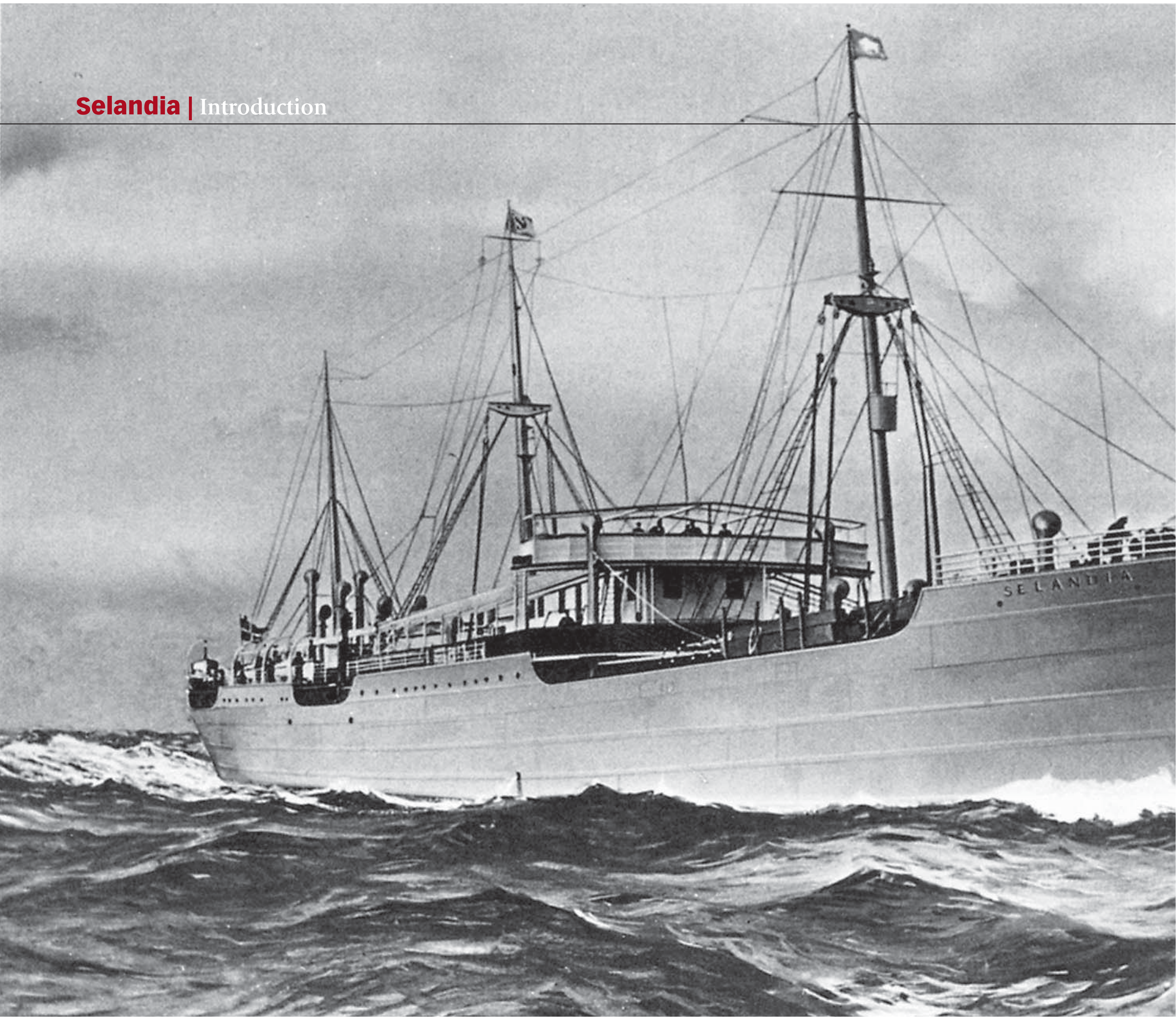


Selandia, the first seagoing motor ship

February 17th 1912 will always be remembered as the day worldwide motorised shipping was born. On that historic date the motor ship *Selandia* was delivered to the Danish trading firm East Asiatic Company by Danish shipyard and diesel engine producer Burmeister & Wain in Copenhagen. She is considered to have been the world's first large oceangoing, diesel-powered ship, with a range previously only achieved by steam-powered vessels that had to rebunker en route.

The *Selandia* created an international sensation on her maiden voyage by travelling more than 22,000 nautical miles to the Far East without any difficulties or having to rebunker. During a stopover in London, Winston Churchill, then first lord of the admiralty, came on board with a large delegation.

Before leaving the *Selandia*, Churchill said, "… It was a pleasant duty for me to congratulate Denmark, the ancient seafaring nation which has shown us the way and taken the lead in a venture that will form an epoch in the development of shipping. This new type of vessel is the most perfect maritime masterpiece of the century!"

The voyage demonstrated the essential economic advantages of diesel power over conventional

ENGLAND PLANS MOTOR SHIP.

Proposed War Vessel Will Be First of Its Kind.

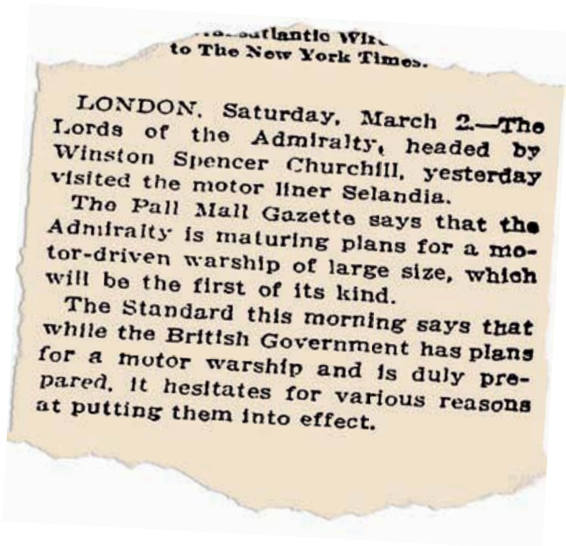
By Marconi Transatlantic Wireless Telegraph to The New York Times.

LONDON, March 1.—It was stated some time ago in well-informed circles that the Admiralty was trying to evolve an internal combustion engine of 10,000 horse power, which would first be tried on an unarmored cruiser. The vessel was to be equipped with a motor, requiring no boilers, stokers, or smokestacks.

According to reports to-day the Admiralty will try to build such a vessel in record time just as was done in the case of the first dreadnought and thereby have the advantage of several months' experience before the German ship, said to be on the stocks, is launched.

The Selandia, which is an oil motor ship, on her trial trip, maintained a speed of thirteen knots and was found to be a good sea-going vessel.

The first seagoing motor vessel, *Selandia,* made the news in international papers



to The New York Times.

LONDON, Saturday, March 2.—The Lords of the Admiralty, headed by Winston Spencer Churchill, yesterday visited the motor liner Selandia.

The Pall Mall Gazette says that the Admiralty is maturing plans for a motor-driven warship of large size, which will be the first of its kind.

The Standard this morning says that while the British Government has plans for a motor warship and is duly prepared, it hesitates for various reasons at putting them into effect.

steam propulsion, mainly efficiency nearly twice as high: less required space, a larger cruising range and much less manpower.

The reliability of the new engine and consequent little downtime for repairs and maintenance were quite remarkable as well.

After the *Selandia* had been in service for more than 12 years and covered a distance of more than 600,000 miles, the chief engineer wrote in his report: "During the past 12 years we have spent ten days in port and this is the only noteworthy delay on account of the machinery. We have often returned from Bangkok and after one or two days' stay in Copenhagen started on the long voyage out to the East again."

In total, the *Selandia* sailed around the world 55 times between 1912 and 1936. This was no easy accomplishment, having been preceded by long years of hard work and research.

The success story of the diesel engine goes back to an ingenious idea by the German inventor Rudolf Diesel 20 years earlier, for which he made a patent application to the Imperial Patent Office in Berlin on February 27th1892.

History of research and development of the marine diesel engine until 1912

It was Diesel's stated aim to develop a combustion engine superior to the then prevailing steam engine. He endeavoured to make – as his son Eugen later wrote – "a better and more economical machine […] and a machine able to use all kinds of fuels: the solid ones, the liquid ones and the gaseous ones." His son recalled: "Sometime between 1889 and 1891, Diesel had the idea of a combustion engine with enormous compression of pure air and the induction of fuel into the hot air at the upper dead centre."

Such a machine could only be made more economical by increasing its efficiency. In a manuscript titled "Theory and Construction of an Economical Thermal Engine", which he sent to Carl Linde, his former teacher at Munich Polytechnic, in February of 1892, Diesel computed an efficiency of 75% for his engine. In reply, Linde told Diesel that he thought this was the right approach. However, he emphasised that Diesel should have given himself a far less ambitious goal, and in a letter dated March 20th 1892 he wrote: "… I shall not forget to add that in my opinion one-third of the theoretical efficiency you computed can be expected to be realistic."

In 1893 Diesel published the paper, "Theory and Construction of a Rational Heat Engine to Replace the Steam Engine and Combustion Engines Known Today", in which he set forth results of his investigations into construction of a power engine more economical than the steam or gas engine.

Shortly thereafter, Ivar Knudsen, a young municipal engineer in Copenhagen, pointed out to the English-born director of Burmeister & Wain, D Halley, that these technical ideas were worthy of special attention. His proposal, however, was received with scant understanding until 1895, when Knud Nielsen, a naval commodore, became director of Burmeister & Wain. Knudsen immediately got in touch with him and propounded the theories of the combustion process as set out by Diesel. At the commodore's urging, Knudsen paid a visit to the Krupp works in Essen as well as the Maschinenfabrik Augsburg (forerunner of MAN in southern Germany), where Diesel's combustion process was tried in practice.

Quantum leaps and criticism

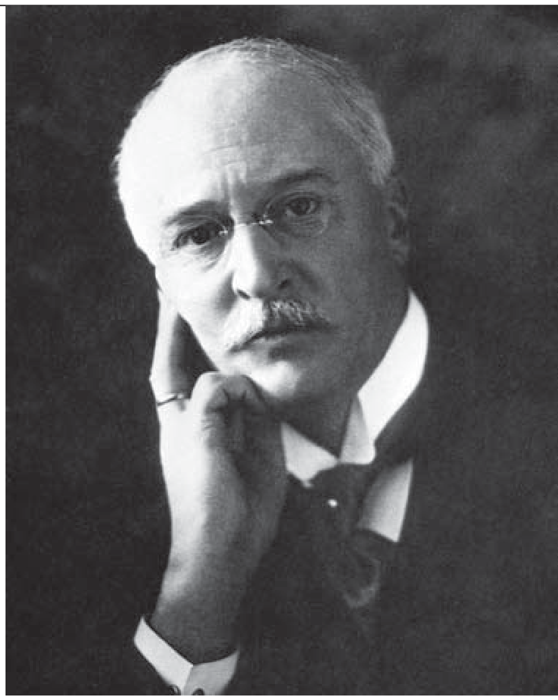
Diesel used the laws of modern thermal dynamics as a basis for the development of his engine. On the one hand, this was the origin of his success; however, it was also somewhat unfortunate because in his Patent 67207, Diesel connected the fundamental idea of his engine to the Carnot process. Since its definition in 1824, it has been considered to be the theoretical process with the highest utilisation of heat. But it can not be practically implemented, neither in a diesel engine nor in any other kind of motor with internal combustion. Also, Diesel soon came to understand that a practical implementation of this Carnot cycle process was impossible. A second patent, DRP 82168, registered on July 12th 1895, protected the working conditions actually possible. But, he applied a certain meticulousness in order not to jeopardise his credibility and his contracts, which he had signed in the meantime with the Maschinenfabrik Augsburg and Krupp to help him build and test the engines: He cleverly avoided revoking the statements made in the first patent and defined the actual thermal dynamic conditions,

which he had meanwhile understood to be the "regulation of combustion". The contradicting theoretical information – which cannot be explained here in detail – did not go undetected by the thermal dynamics experts of his time, of course, and were the reason for repeated criticism. It was against this background that he was exposed to unusually harsh attacks from participants of the annual meeting of the Schiffbautechnische Gesellschaft (German Society for Maritime Technology; STG) in 1912, where he gave a lecture on "The development of the diesel engine". Privy Councillor Professor Dr Riedler and Professor Dr Nägel tried to belittle Diesel's merits. They only partially accepted his indisputable personal contribution to the development of the diesel engine and implicitly called his invention into question. The underlying conflict – which, typically enough, was not addressed openly – was over the validity of Diesel's patent applications, in which he had made claims that were never implemented in the real diesel engine. Considering the fierce and unobjective personal attacks on Diesel at the STG annual meeting, the management deemed it necessary at the time to give him the opportunity of writing a postscript as an addition to his summary. So Diesel took a stand on the issue:

"[…] Finally Mr Riedler (as did many before him) raises the question: 'Which of Diesel's findings have been utilised, were these findings correct or were they wrong?' Did I not try hard, also not for the first time, to show how I, bit by bit, after innumerous aberrations, eventually found the final procedure? Don't you see, my whole account is the very story of this slow development process with all its variations and failures? Did I not repeat countless times that the real engine is a 'compromise' between an ideal and what is actually feasible"?

The "failures" and "compromises" refer to the two objectives that Rudolf Diesel had originally tried to achieve: the degree of efficiency of 75% and combustion of any kind of fuel.

The first operational diesel engine, built after three and a half years of experimentation at the Maschinenfabrik Augsburg with the participation of Krupp, successfully passed four series of tests at different revolutions on February 17th 1897. The engine had a power of 17.82 hp at rated speed – called the "number of normal revolutions" by Moritz Schröter, the laboratory's director at the time – and an efficiency of 26.2%, corresponding to fuel consumption of 238 g/hp-hr. This was an important milestone, and on March 11th 1897 the parties involved – Maschinenfabrik Augsburg and Krupp – certified it as follows: "After a marketable engine of the Diesel system has been built and tested, we now want to start serial production of the diesel engine." Linde's forecast of efficiency had turned out to be rather exact, and he and Diesel also had to lower their sights on fuel use.



The German inventor and mechanical engineer Rudolf Diesel (1858 - 1913)

Choice of fuels

In his first patent Diesel wrote, "For the implementation of the procedure, all fuels can be used in all states of aggregation." This approach is understandable insofar as black coal was the prevailing fuel at the time and liquid fuels were neither available in sufficient quantities nor could allow economical operation of such an engine due to their high


PATENT-URKUNDE

№ 67207

AUF GRUND DER ANGEHEFTETEN BESCHREIBUNG UND ZEICHNUNG IST DURCH BESCHLUSS DES KAISERLICHEN PATENTAMTES

an Rudolf Diesel, Ingenieur, in Berlin

EIN PATENT ERTHEILT WORDEN.

GEGENSTAND DES PATENTES IST:

Arbeitsverfahren und Ausführungsart für Verbrennungskraftmaschinen.

ANFANG DES PATENTES: 28. Februar 1892.

DIE RECHTE UND PFLICHTEN DES PATENTINHABERS SIND DURCH DAS PATENTGESETZ VOM 7. APRIL 1891 (REICHS-GESETZBLATT FÜR 1891 SEITE 79) BESTIMMT.

ZU URKUND DER ERTHEILUNG DES PATENTES IST DIESE AUSFERTIGUNG ERFOLGT.

Berlin, den 23. Februar 1893.

KAISERLICHES PATENTAMT.

Beglaubigt durch Kank

Bureau-Vorsteher des Kaiserlichen Patentamtes.

A patent that revolutionised the world of propulsion

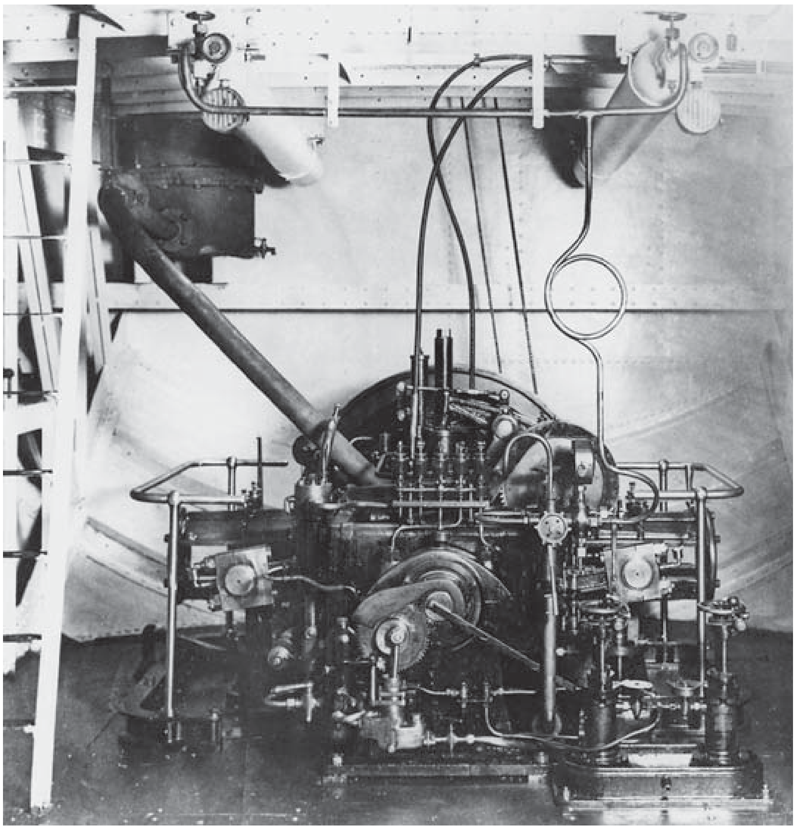
price. The best fuel for combustion in the diesel engine first had to be found in many test series. So from 1897 through the period of its development as an operational engine, it operated mainly on kerosene. But given the price of 18 German marks for 100 kg, more appropriate fuels had to be found for a successful introduction on the market. Tests were done with brown coal tar oil, toluene, powdered coal, spirits, benzene, crude oil and gasoil. In 1899 in Augsburg, Diesel carried out tests to assess the combustion of powdered coal. They were unsuccessful, though. Nonetheless, until his death in 1913 he considered the "powdered coal engine" to be "technically feasible", as he explicitly stated in 1912 at a meeting of the STG. To this day, economical operation of a powdered coal engine has proven impossible despite comprehensive research towards this end. Aside from this restriction, the acceptance of different kinds of fuels – something that Diesel reiterated – is the key to the engine's success.

International breakthrough at the turn of the century

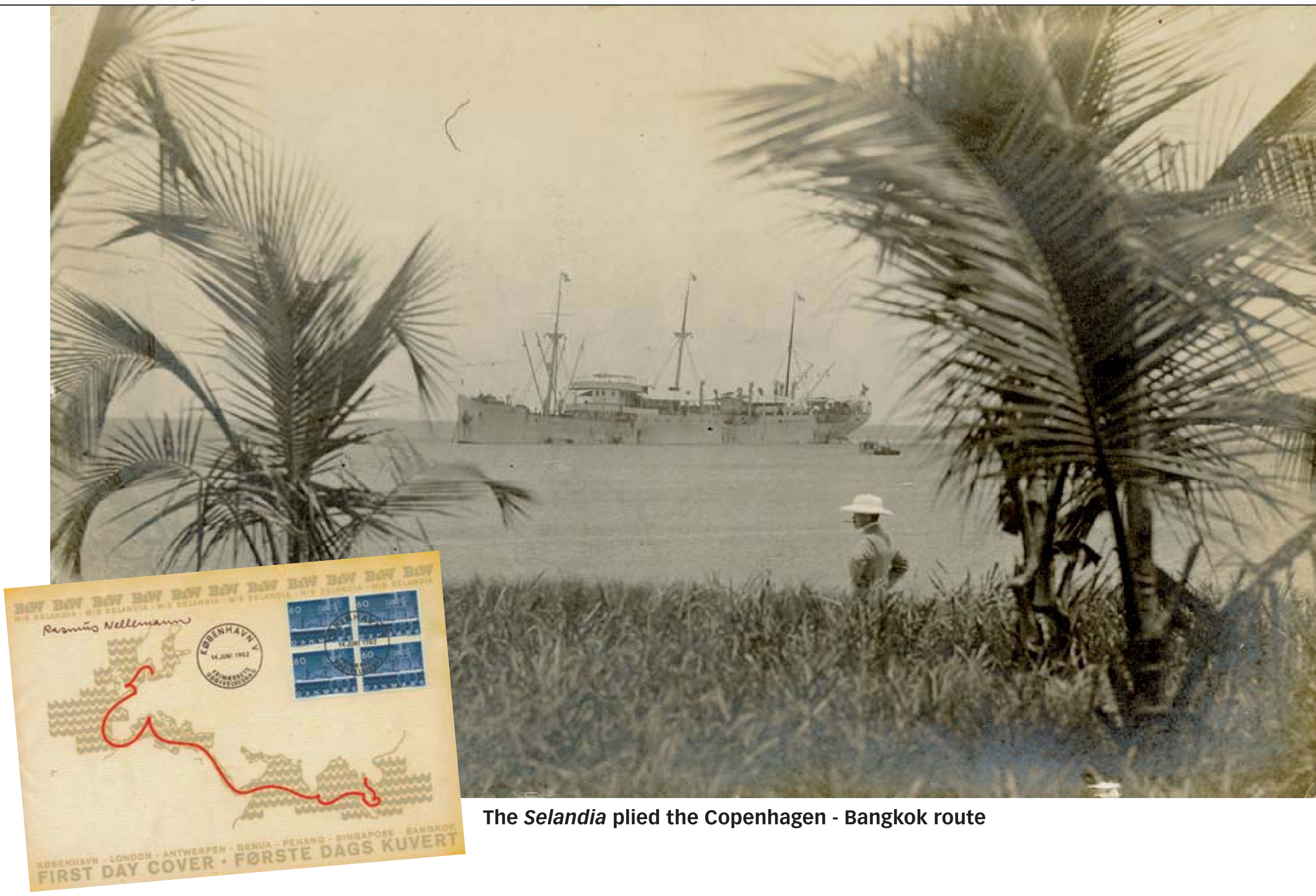
After the Augsburg trials, the new engine was continuously developed further – an efficiency of 30.2% was achieved as early as October 1897 – and more test engines were built, arousing increasing interest in professional circles. At the World's Fair (Exposition Universelle) held in Paris in 1900, the diesel engine was awarded the Grand Prix, the highest prize, constitut-

ing its international breakthrough. In the following years, the Maschinenfabrik Augsburg was instrumental in advancing the introduction of the engine and brought it to market maturity over grave doubts by the day's experts and innumerable setbacks. In 1908 MAN* decided to cease production of steam engines due to the diesel engine's success, finally implementing the decision in 1912.
During this time, the number of patents that Diesel registered increased enormously: from 87 in 17 countries in 1898 to 141 in 37 countries in 1904. After expiration of the main patents in 1907/08, about half of the 206 engine manufacturers in Germany at the time built diesels. In 1913 a total of 774,000 hp (570,000 kW) were installed in Germany, accounting for approximately 45% of the diesel power available worldwide. However, its application as ship propulsion was still in the early stages of development.

*In 1908, the Vereinigte Maschinenfabrik Augsburg und Maschinenbaugesellschaft Nürnberg AG, Augsburg ("United Machine Works Augsburg and Nuremberg Ltd"), which came into being through the 1898 merger of Maschinenbau-AG Nürnberg (founded 1841) and the Maschinenfabrik Augsburg AG (founded 1840), was renamed Maschinenfabrik Augsburg Nürnberg AG, Augsburg, or, in short, MAN.



One of the first diesel engines (installed on board the *Vandal*)



The *Selandia* plied the Copenhagen - Bangkok route

The history of *Selandia:* 1912 - 1942

After the diesel engine had been successfully used for several stationary purposes, its possible application for marine propulsion began to attract wide interest – all the more so because, in contrast to conventional steam propulsion in similar weight and size classes, the space for a steam generator could be saved. But an important difficulty had to be overcome: The engine had to master both directions of rotation, for headway and reversing, that is, it needed to be reversible.

First attempts at marine propulsion

Frederic Dyckhoff, a friend of Diesel's, had the first idea how to solve this problem. It was patented in the names of Dyckhoff, MAN and Krupp. Dyckhoff then built a diesel engine with a reversing gear according to the patent. Completed in 1901, it had 15 hp but the reversing mechanism did not run failure-free, so the engine was unreliable for ship propulsion. A second attempt, by Sauter, Harlé & Cie, Diesel's licensee in Paris, in which a reversible 25-hp engine was installed on a river vessel called *Petit Pierre*, also failed because of inadequate construction.

The next attempt at propelling a ship with a diesel engine came in St Petersburg, Russia, in 1903. The Baku-based oil company Bros Nobel, which operated a tanker fleet from the Black Sea port of Batumi, equipped the 75m-long river vessel *Vandal* with three 120-hp, four-stroke diesel engines by the Swedish company Aktiebolaget Diesels Motorer. A diesel-electric drive concept was used, avoiding the reversing problem.

An example of a diesel installed as an auxiliary engine on a sailing ship was the coastal schooner *Orion*, built in 1907 and equipped with an engine from Swedish manufacturer AB Motorer. The same company also delivered the 120-hp, 300- rpm, two-stroke reversible engines for two 350-dwt cargo vessels, *Rapp* and *Schnapp*, which were commissioned in 1908 and sailed in the Baltic and North seas.

In the same year, the 4,000-dwt Caspian Sea tanker *Djelo*, powered by two 500-hp, 150-rpm engines, was built in Russia. In 1910, the *Robert Nobel*, a 1,740-dwt tanker with reversible engines, was delivered.

A lightweight 200-hp V-8 diesel engine, intended for Emanuel Nobel's yacht *Intermezzo*, was also built in 1910. It served as a prototype for Nobel's lightweight submarine diesel engines built between 1910 and 1912.

The tanker *Vulcanus*, 60m long and built by the Netherlands Shipbuilding Co in 1910, was driven by a reversible diesel engine, too, namely a 450-hp, four-stroke model by the Dutch company Werkspoor. This engine is said to have still been functional when the ship was dismantled in 1931.

The world's first oceangoing diesel-powered ship

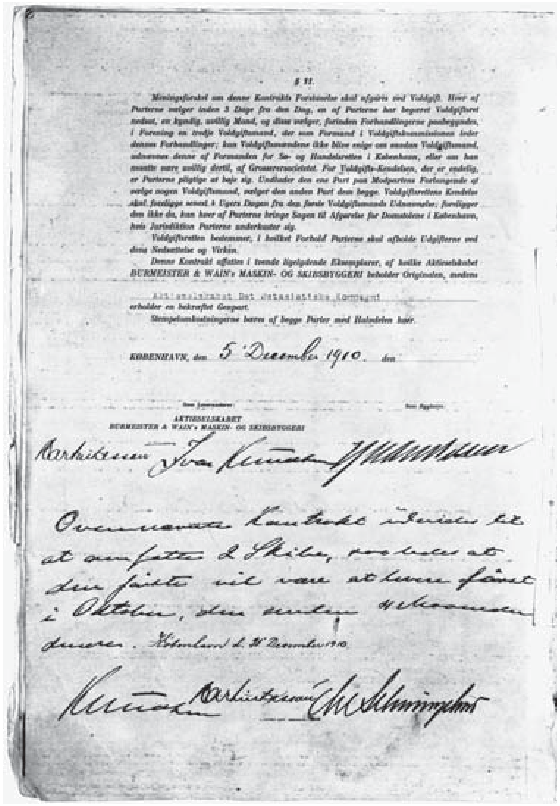
The cargo and passenger vessel *Selandia*, commissioned in 1912 by the Copenhagen-based East Asiatic Company (EAC), is generally considered to have been the first oceangoing motor vessel. Though the *Selandia* was not, in fact, the first diesel-powered seagoing vessel, she set the pace for large marine diesel engines and went down in history due to her size and operational reach.

With a length of 112m, loading capacity of 7,400 tonnes and gross tonnage of 4,964, the *Selandia* was about five times bigger than the *Vulcanus* in terms of displacement and had four times the tonnage. The engine output of 2 x 1,250 hp was also approximately five times higher than the power of the *Vulcanus*.

The *Selandia* was built by the shipyard and engineering works Burmeister & Wain (B&W) and marked the beginning of a new era in navigation.

She was propelled by two sets of B&W eight-cylinder, four-stroke diesel engines – each working on one propeller, bringing the total power to 2,500 hp. B&W guaranteed a specific fuel consumption of 175 grams of oil with 10,000 kcal/kg per hp-hr for this particular engine type, which had already proven itself in several applications as a stationary engine with four cylinders and 600 hp.

In contrast to conventional steamers, there was no funnel; instead, there were hidden exhaust ports at the aft mast.


§ 11.

Meningsforskel om denne Kontrakts Forstaaelse skal afgøres ved Voldgift. Hver af Parterne vælger inden 3 Dage fra den Dag, en af Parterne har begæret Voldgiftsret nedsat, en kyndig, uvillig Mand, og disse vælger, forinden Forhandlingerne paabegyndes, i Forening en tredje Voldgiftsmand, der som Formand i Voldgiftskommissionen leder dennes Forhandlinger; kan Voldgiftsmændene ikke blive enige om saadan Voldgiftsmand, udnævnes denne af Formanden for Sø- og Handelsretten i København, eller om han maatte være uvillig dertil, af Grosserersocietetet. For Voldgifts-Kendelsen, der er endelig, er Parterne pligtige at bøje sig. Undlader den ene Part paa Modpartens Forlangende at vælge nogen Voldgiftsmand, vælger den anden Part dem begge. Voldgiftsrettens Kendelse skal foreligge senest 4 Ugers Dagen fra den første Voldgiftsmands Udnævnelse; foreligger den ikke da, kan hver af Parterne bringe Sagen til Afgørelse for Domstolene i København, hvis Jurisdiktion Parterne underkaster sig.

Voldgiftsretten bestemmer, i hvilket Forhold Parterne skal afholde Udgifterne ved dens Nedsættelse og Virken.

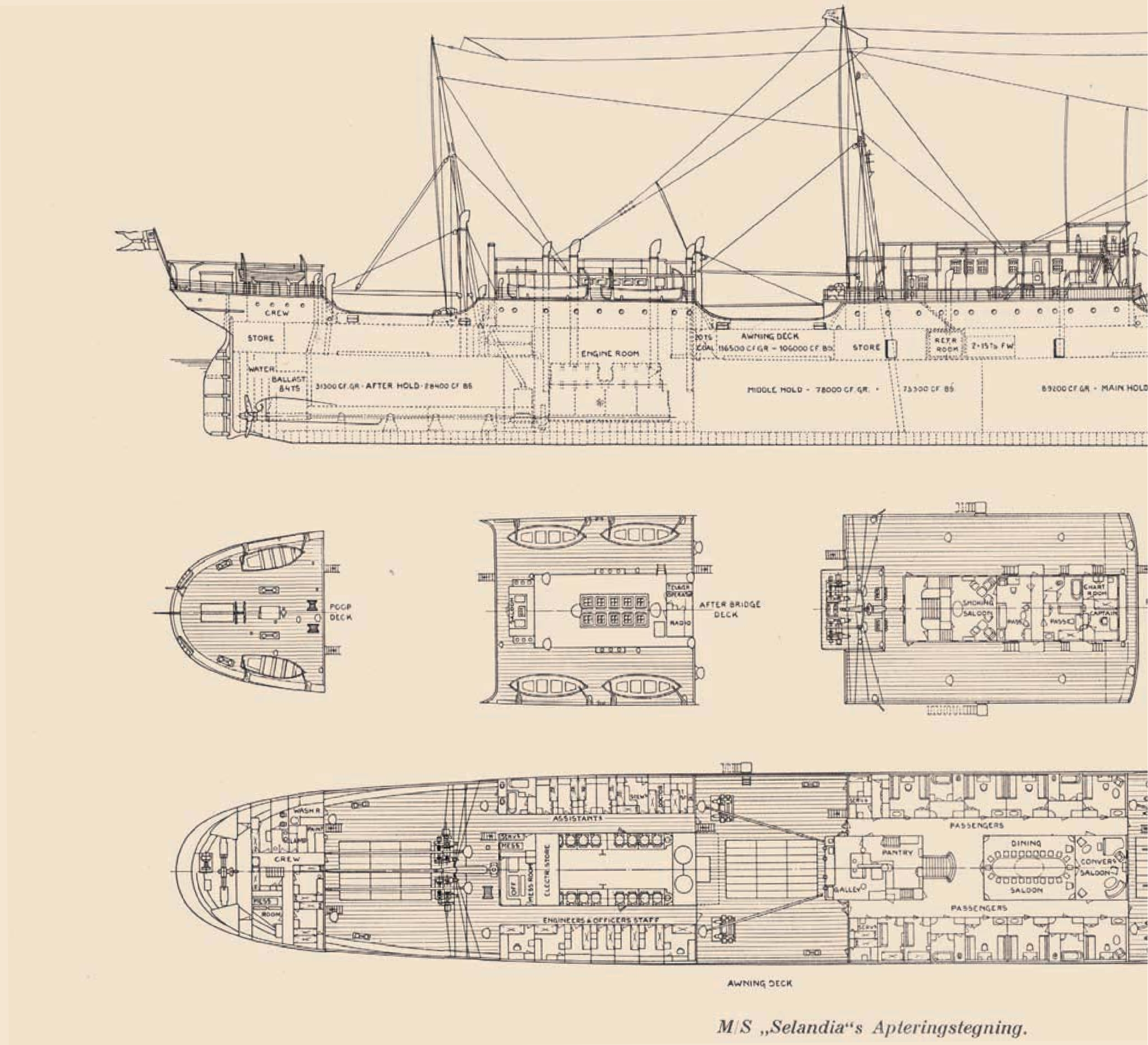
Denne Kontrakt affattes i tvende ligelydende Eksemplarer, af hvilke Aktieselskabet BURMEISTER & WAIN's MASKIN- OG SKIBSBYGGERI beholder Originalen, medens Aktieselskabet Det Østasiatiske Kompagni erholder en bekræftet Genpart.

Stempelomkostningerne bæres af begge Parter med Halvdelen hver.

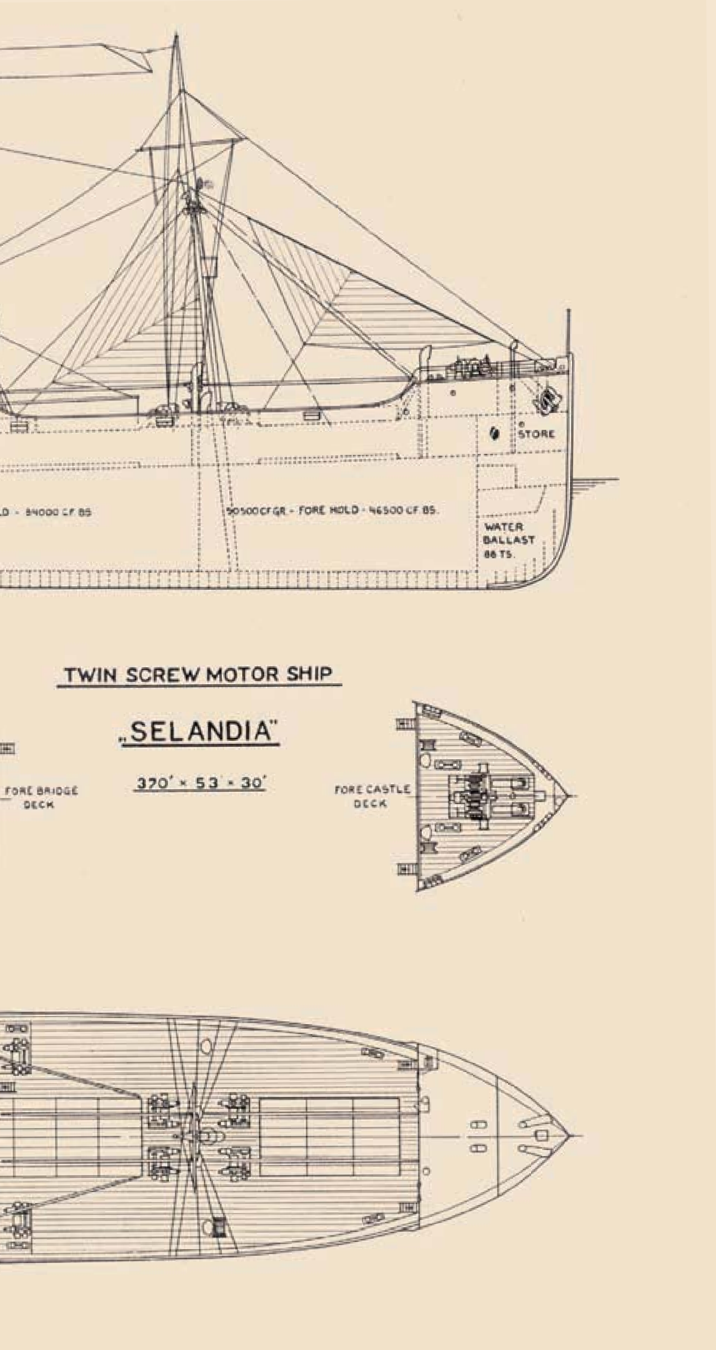
KØBENHAVN, den 5 December 1910. den

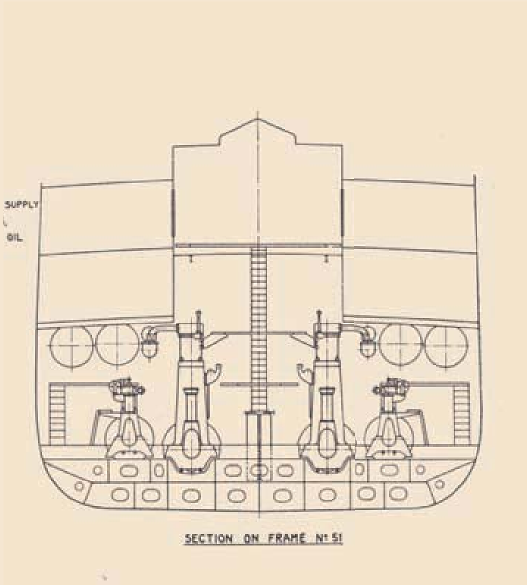
AKTIESELSKABET BURMEISTER & WAIN's MASKIN- OG SKIBSBYGGERI

Part of the construction contract

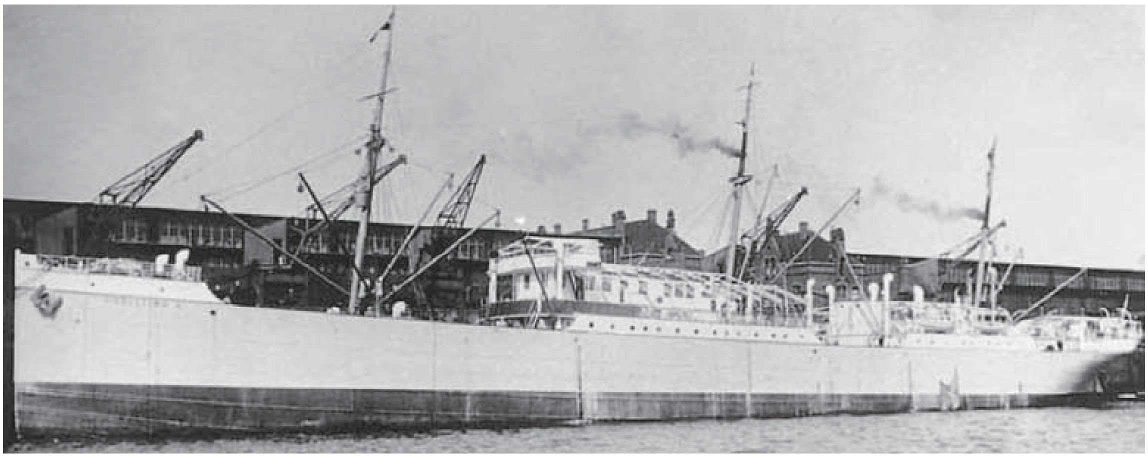


M/S „Selandia"s Apteringstegning.





Draft of *Selandia:* The cargo and passenger vessel, built by the shipyard and engineering works Burmeister & Wain (B&W), was 112m long, had a loading capacity of 7,400 tonnes and a gross tonnage of 4,964.
Compared with a steamer of similar size, the *Selandia* only needed approximately a third of the engine staff The vessel was propelled by two sets of B&W eight-cylinder, four-stroke diesel engines – each working on one propeller, bringing the total power to 2,500 hp.
The *Selandia* was delivered to her owner on February 17th 1912



***Selandia*'s sister ship *Fiona* went as *Christian X* into service for HAPAG**

Another noteworthy distinction of the *Selandia* was her not only being a cargo ship but also having comfortable accommodations – in spacious, luxurious cabins with bathrooms – for a large number of passengers.

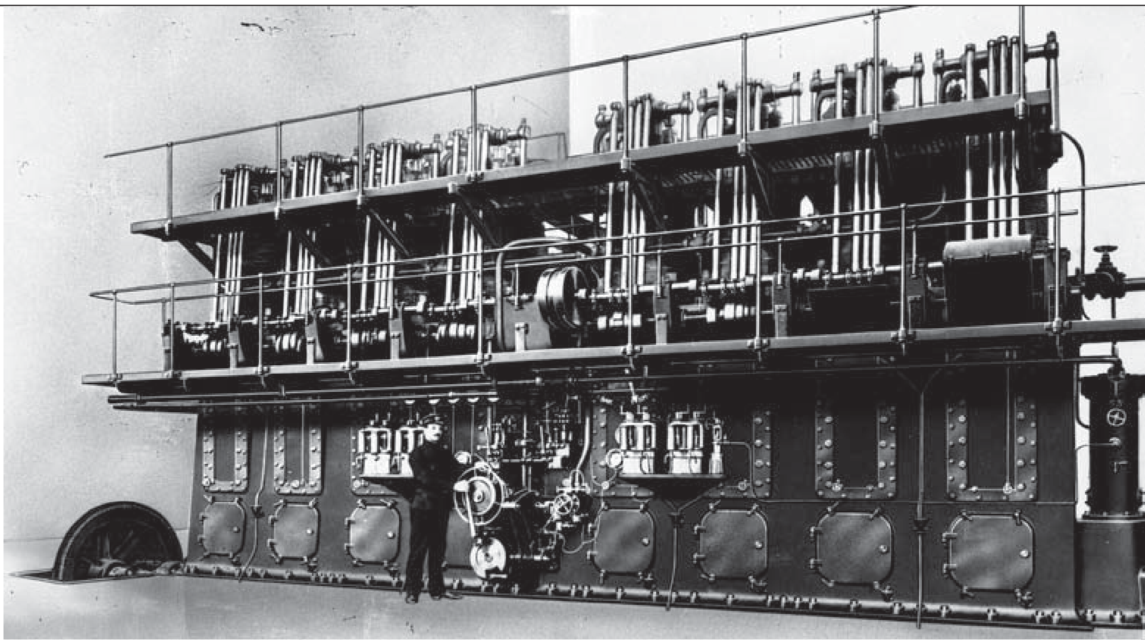
Sister vessel

The *Selandia*'s sister ship *Fionia* also attracted wide interest when she was presented at Germany's annual Kiel Week sailing event in 1912 – even German Emperor Wilhelm II came aboard. And the then director general of the German shipping company HAPAG, Albert Ballin, was on board the *Fionia* during her demonstration voyage. Ballin, who had been convinced of the advantages of the diesel engine early on, was so taken with the new propulsion technology that he immediately bought the ship from the chairman of EAC, H.N. Andersen.

Renamed the *Christian X*, after the newly crowned Danish king, she travelled to the West Indies on her maiden voyage as a HAPAG vessel on July 23rd 1912.

Construction and delivery

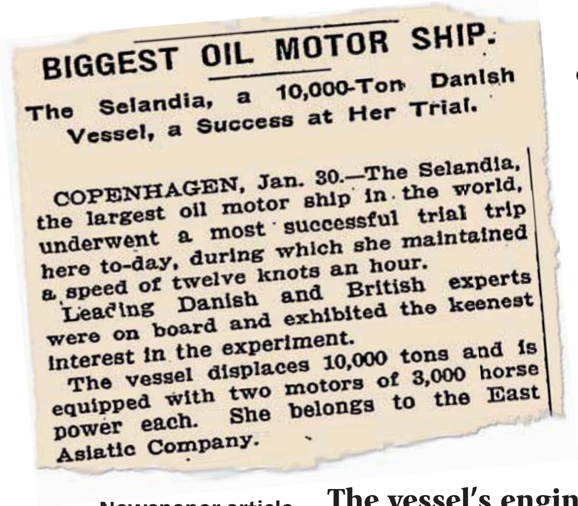
In the autumn of 1911, the *Selandia* was launched at Refshaleøen, an island in Copenhagen's harbour.



Portside main engine of the *Selandia*

The name given to the yet unfinished vessel was a Latinisation of Sjælland, an island on which Copenhagen is partly located. Only a few months later it was a byword in shipping circles all over the world – a new era in the history of shipping had begun.

Sea trials commenced in 1912 and initial difficulties were small and few. The manoeuvring capacity of the ship was all that could be wished for. She logged a steady 11 to 12 knots, and when tried in ice, the ship stood the test with ease. On February 15th 1912, the *Selandia* made her last trial trip up the Sound. Everything ran smoothly and according to schedule, so Burmeister & Wain was able to deliver the vessel to the East Asiatic Company on February 17th. The delivery was made in a simple but dignified manner, and the new owners were so satisfied with the ship that other



BIGGEST OIL MOTOR SHIP.

The Selandia, a 10,000-Ton Danish Vessel, a Success at Her Trial.

COPENHAGEN, Jan. 30.—The Selandia, the largest oil motor ship in the world, underwent a most successful trial trip here to-day, during which she maintained a speed of twelve knots an hour.

Leading Danish and British experts were on board and exhibited the keenest interest in the experiment.

The vessel displaces 10,000 tons and is equipped with two motors of 3,000 horse power each. She belongs to the East Asiatic Company.

Newspaper article in the New York Times (January 30th 1912)

orders quickly followed. After taking over the *Selandia*, the East Asiatic Company made small trips with her, inviting members of Denmark's royal house, the diplomatic corps, parliament, municipal authorities and the Copenhagen city council as well as other celebrities. Invitations were also issued to famous technicians from shipyards with which Burmeister & Wain was in contact.

The vessel's engines

Selandia's main engines were eight-cylinder, four-stroke die¬sels, the number of revolutions at normal speed being 140 per minute. Starting in either direction took place by means of compressed air. The camshaft from which the valves were moved was arranged to be displaced lengthwise when all the rods with the attached rollers that lifted the valves had been removed from the cams by means of a crank motion. Hence it was placed in a position suitable for either the "ahead" or "astern" motion.

Reversing from "full speed ahead" to "full speed astern" could be carried out in less than 20 seconds. When the reversing gear had been brought into the proper position by the reversing engine, starting took place by moving a handle, by which means air at a pressure of 20 atmospheres was fed to the cylinders through the starting valve, which began to work automatically when the compressed air was admitted. When the engine, by means of the compressed air, had reached a sufficient speed of revolution, (this occurred almost immediately), the handle was moved further, the air was shut off, the starting valves closed themselves, the engine was fed oil and then worked as an ordinary diesel engine at the speed required. The speed depended on the position given to the abovementioned handle, which regulated the supply of fuel oil. So reversing was executed by means of two handles, corresponding to the two levers on an ordinary steam engine.

The speed of the engine at sea was controlled by an Aspinall governor, which shut off the supply of fuel oil when a sudden rise in the number of revolutions occurred beyond the normal, and only opened again when the revolutions had dropped to a certain pre-arranged number. As the engine had eight cylinders, and the cut-off at the start was above 0.6 of the stroke, the engine could always be started at any given crank position.

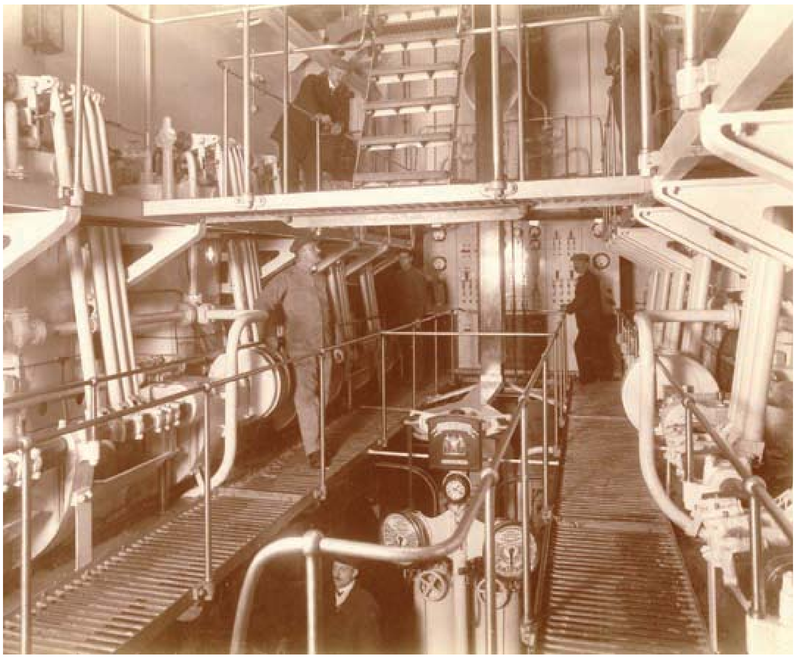
On the shaft was a small flywheel 2m in diameter. It had a toothed-wheel gearing on the periphery driven by a worm so that the main engine could always be turned by means of an electric motor.

On each main engine was also an air compressor that compressed air from 20 atmospheres up to 60

atmospheres for the injection of fuel oil into the cylinders. The compressors could be adjusted for half or complete filling. Half filling was used when each pump supplied its engine. If a pump was damaged, the other one was switched on to complete filling and would supply sufficient air for the injection of fuel oil into both main engines. As a back-up for the first compression to 20 atmospheres, the exhaust valve on one of the cylinders of the main engine could be removed and replaced by a delivery valve, allowing the cylinder to work as a compressor that compressed the air to 20 atmospheres. The engine then operated with only seven cylinders, but trials had shown that reversing and operation were in no way impaired.

The auxiliary engines were of 250 indicated horsepower each and worked at about 230 revolutions; both were fitted with a dynamo and air compressor. The latter was calculated to supply air at a pressure of 20 atmospheres, which was used to reverse the main engines and provide the air compressors of the main engine with air for fuel injection. When the ship was at sea, it had been intended that the dynamo (which was placed on the same shaft) be used for lighting and working operating the various auxiliary motors, such as those for winches, pumps, refrigerating machinery, etc.

There were two auxiliary engines on board the *Selandia* in order to have a spare. The auxiliary machinery also included two sets of electrically driven lubricating pumps, circulating pumps, hot and cold water sanitary pump and bilge pump, two electric transformers, a refrigerating plant and a donkey boiler to provide steam for fire-extinguishing in the holds and operate a steam-driven compressor able to compress air to 60 atmospheres. The electrically



The engine room of the *Selandia*

The *Selandia* was not only a cargo ship, but also offered comfortable accommodations for passengers


MOTOR STEAMER'S LONG TRIP

The Sealandia on Her Way to Bangkok, Burning Oil Only.

By Marconi Transatlantic Wireless Telegraph to The New York Times.

LONDON, Feb. 27.—The motor liner Sealandia has arrived at London on her maiden trip to Bangkok. Her voyage tends to confirm the highest expectations raised by her trial performances at Copenhagen. Interviewed yesterday, M. Knodsen, managing technical director of the Danish East India Company, which owns the Sealandia, said:

"In our voyage we are using 1,000 tons of oil, leaving room for 6,600 tons of cargo. An ordinary steamship of the same size for a similar voyage would require 5,000 tons of coal, leaving room for only 2,000 tons of cargo.

driven lubricating pumps drew the oil (each from its own tank placed under the engine) and forced it through the main bearings, crankshaft, connecting rod brasses and hollow-bored connecting-rod to the crosshead brasses, then through the piston rod to the top of the oil-cooled piston and back through the piston rod to the guides. Cooling the oil took place on the water-cooled guide faces. Further cooling could be carried out by pumping oil through an oil cooler formed as a surface condenser. From the two compressors of the auxiliary engines, which had been designed as three-stage compressors, pipes were led from the intermediate cooler with an air pressure of about eight atmospheres to the siren, which was fitted on the mast.

At the top of the engine room casing were two settling tanks into which fuel oil was fed by an air-driven pump in the engine room; each tank contained sufficient oil for 12 hours of normal work. The object of

Passengers' facilities on board the *Selandia*

H.N. Andersen welcomes Winston Churchill

these tanks was to separate any water from the oil so that comparatively pure oil could be fed to the engines.
The deck machinery was electric throughout; all winches were electrically driven, as were the windlasses and steering engine, which was of a new construction type (Hele-Shaw Martineau hydraulic electric system) and worked well in every respect.

Accommodations and passengers' facilities

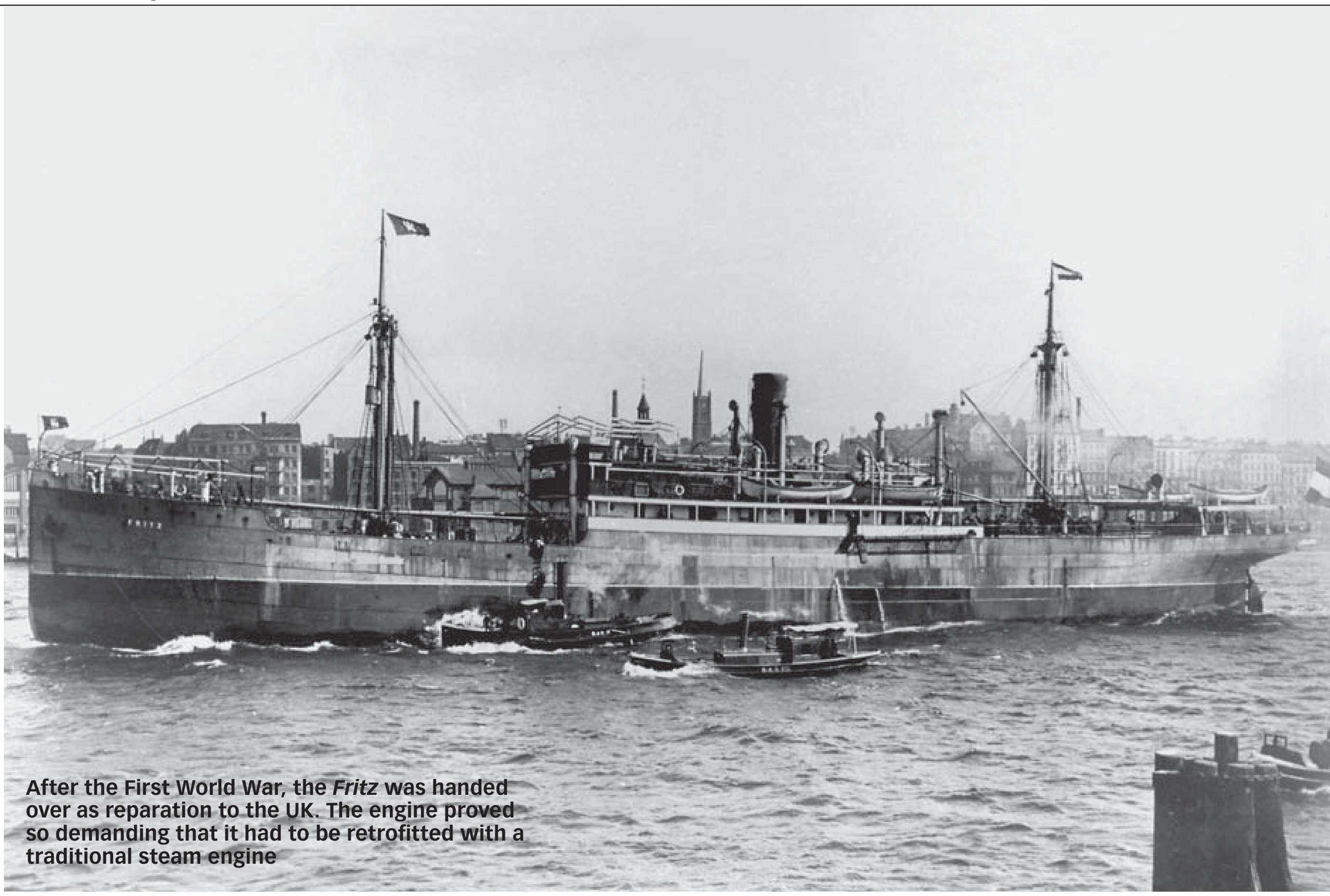
Arrangements for the enhancement of passengers' comfort were considered to the last detail. All midship accommodations were luxuriously equipped, their designer, Danish architect Carl Brummer, having based his ideas on the EAC's past experiences. The highlight was the large, well-lighted cabins and elegantly decorated rooms meant to give passengers the impression of being in a stately private residence and not on a ship. The cabins were unusually spacious and provided with a bed that could mechanically be transformed into a sofa. Adding to the comfort were a large clothes wardrobe, large washstand with hot and cold running water, a desk and chairs. The bathrooms and toilets were situated adjacent to the cabins so that passengers had direct access to them.
There were single- and two-berth cabins in the midship accommodations area, along with a large dining saloon and lounge. Their ceilings were raised above the bridge deck, giving them a lofty appearance and a pleasant lighting effect.
The space between the dining saloon and elegant stairway was arranged as a hall, with the stairway leading to the accommodations above. They consisted of a cosy smoking saloon and a few cabins furnished with special luxury — both a sleeping apartment and sitting room. In front of them were the captain's cabin and chartroom. An additional smoking saloon on the boat deck was reserved for the officers.

The maiden trip

The voyage to Bangkok took place without any mishaps. On April 20th, the ship anchored opposite the large offices of the East Asiatic Company there. The engines were overhauled after running for 980 hours on end, and on May 1st the *Selandia* weighed anchor and sailed for Copenhagen, arriving on June 26th. The ship's return was celebrated as a great event – thousands of enthusiastic citizens gave her a hearty welcome, from the quay as well as from surrounding ships. The voyage had been accomplished on schedule and to the satisfaction of everyone concerned.

Selandia's journey

The *Selandia* was deployed in the Pacific during the First World War. Afterwards she plied the Copenhagen – Bangkok route. In 1936, she was sold to Norway and renamed the *Norseman*. Due to severe damage she was decommissioned from 1938 to 1940.
Eventually the vessel was sold to the Helsinki-based Finland-Amerika-Linjen O/Y. After another renaming, to *Tornator* with registration in the United States, the vessel was chartered to Japan. After running aground on January 26th 1942 in Omaisaki Bay, Japan, the *Tornator* broke in two and sank four days later. The remarkable history of this pioneering ship had ended, but the development she had begun went on.



After the First World War, the *Fritz* was handed over as reparation to the UK. The engine proved so demanding that it had to be retrofitted with a traditional steam engine

Further developments of diesel engine propulsion in sea shipping

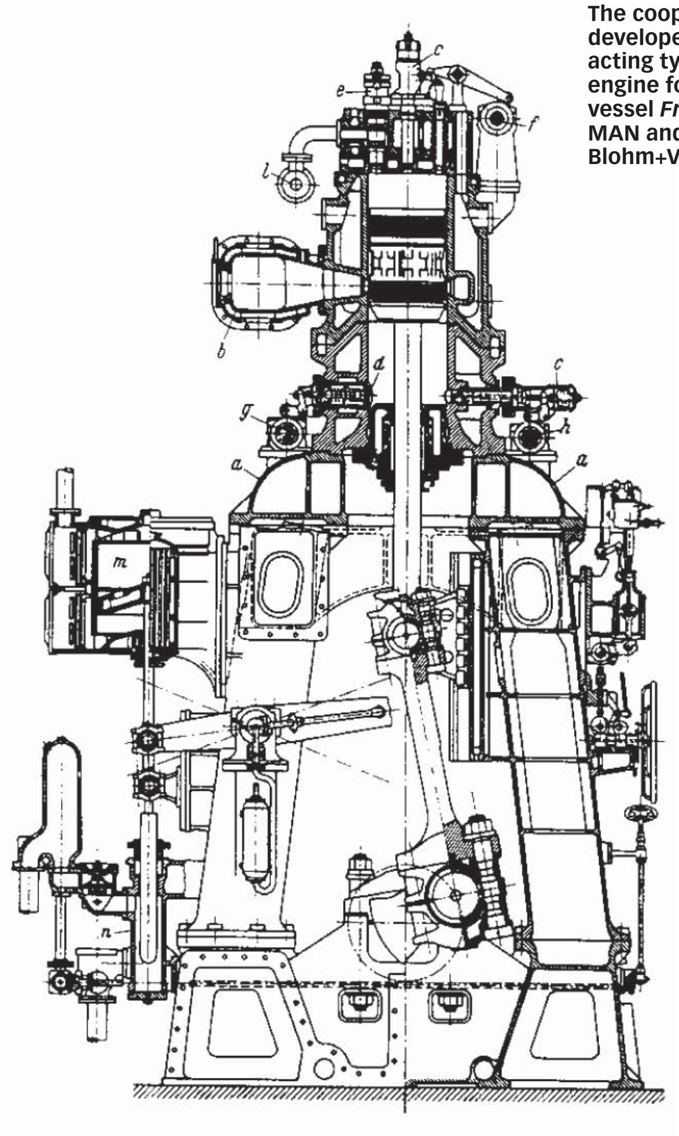
The main development phase of diesel engines in the early 20th century was characterised by many activities and experiments. There were designs according to the four-stroke and two-stroke principle, single-acting and double-acting, engines with additional steam admission as well as engines with a single piston, double piston and opposed piston. In 1912, the first vessel with a two-stroke crosshead engine – the *Monte Penedo*, a 6,500-dwt cargo ship – was commissioned for the German shipping company Hamburg Süd. Its two four-cylinder engines had an output of 850 hp (625 kW) each. In 1913,

the register of the classification society Germanischer Lloyd already listed 64 motor vessels; in 1914, the number increased to 98.

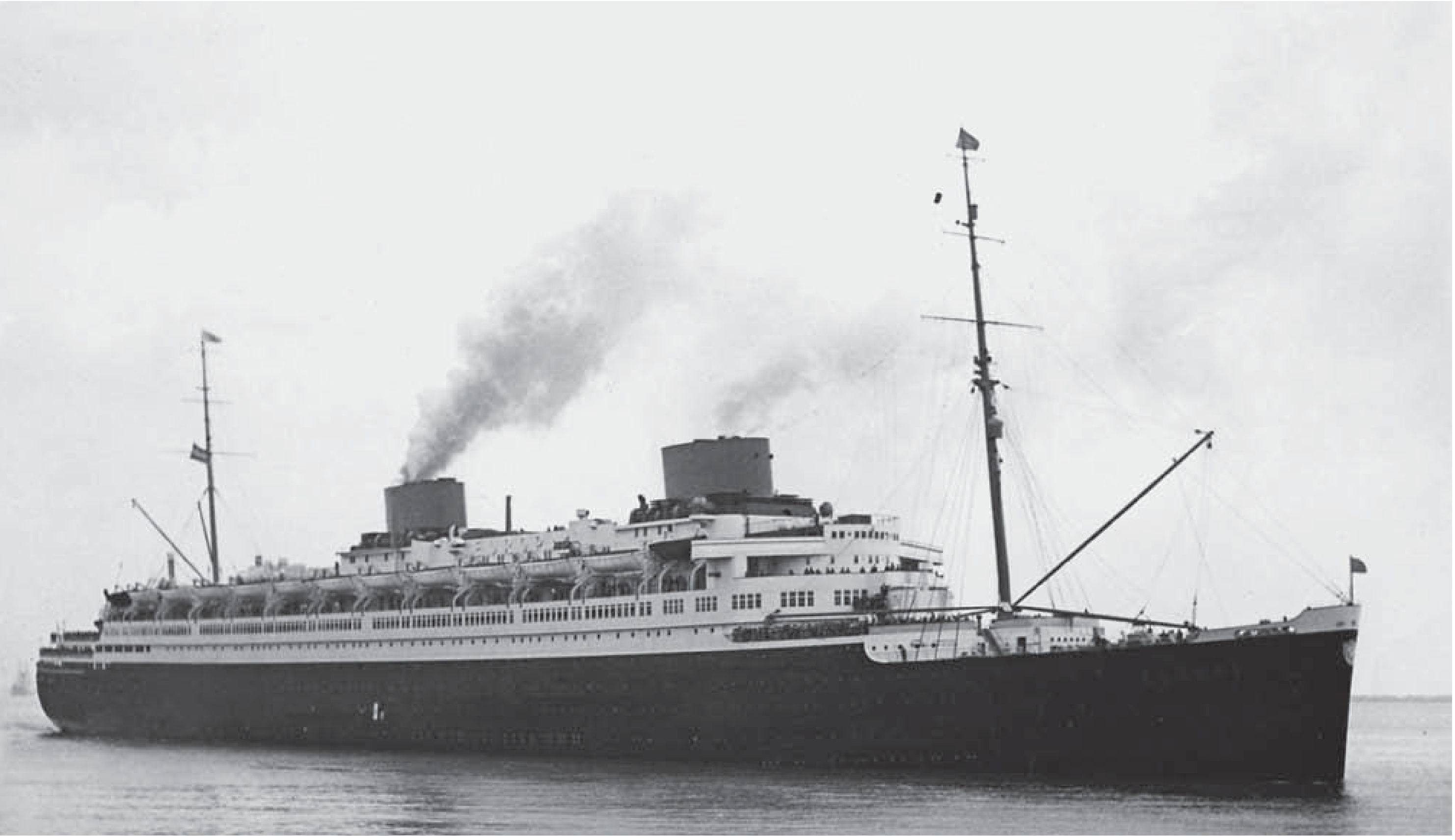
Ballin's enthusiasm for motor vessels gave rise to the subsequent involvement of his shipping company, HAPAG, (Hamburg American packet-shipping joint stock company). The *Primus* – launched in March 1912 at the Bremen shipyard AG Weser – was originally intended to be the shipping company's first motor vessel. But the complicated opposed pistons of the Junkers type, in which every cylinder had four pistons, did not work adequately, which hardly seems surprising today. The ship was renamed *Kribi* in 1914 and refitted for steam propulsion. But the HAPAG was not discouraged, and on March 11th 1914 it took delivery of the *Secundus*, its first motor vessel (or oil engine ship, as they were called at the time). Built by Hamburg-based Blohm+Voss, the ship was equipped with two single-acting, two-stroke engines of 990 kW (1350 / 1500 hp) each and travelled at a speed of 11.5 knots. Her first trip, to New Orleans, ran trouble-free.

In Germany, the development of ship propulsion with diesel engines was strongly advanced by the very fruitful cooperation between MAN and Blohm+Voss. In 1909, the two signed a licence contract for the construction and development of a double-acting, two-stroke diesel engine. In early February 1911, Blohm+Voss invited MAN to join the first test run of such an engine, which was later used for propulsion on the motor vessel *Fritz*.

The completion of the *Fritz*, which Blohm+Voss built at its own expense, was delayed due to some difficulty developing the new double-acting engine type. In 1915 the first test run was successful. However, the First World War put a sudden end to this upcoming development: Although Blohm+Voss applied for approval from the victorious Allies, no more test runs were allowed to take place. MAN nevertheless acknowledged the considerable technological achievements of Blohm+Voss in the development of diesel-engine ship propulsion, noting in a historical review: "With these two newbuildings, but particularly with the two engines for the ship *Fritz*, Blohm+Voss marked a milestone in the history of marine diesel engines. At the same time, this had a very positive effect on the development of MAN engines and they contributed to the fact that a number of potential clients actually bought the licence for single-acting and double-acting two-stroke engines by MAN." Recognising their merits, in 1917 MAN paid back the licence fees to Blohm+Voss for the time between 1909 and 1914.



The cooperatively developed double-acting type of engine for the vessel *Fritz* by MAN and Blohm+Voss



The *Europa* made headlines in 1933 with record speeds of 27.93 knots, which were far beyond the possibilities of diesel engines at that time

The fate of the *Fritz* showed that diesel engine technology of that era was still extremely complicated on board a ship and made high demands on engine room staff. The engines of the newbuilding, which had to be handed over to Great Britain after the war, were replaced by steam propulsion because the British were unable to handle the diesels. This is also one of the main reasons why the diesel engine – despite all of its indisputable advantages as ship propulsion – was so slow to prevail over the steam engine.

After the First World War

The 1920s saw turbulent development in shipbuilding and ship propulsion. It was a time characterised by the search for the most appropriate kind of ship propulsion. Three kinds of propulsion systems were competing with each other: the steam engine, the steam turbine and the diesel engine. Diesel engine propulsion gears needed to be developed further in order to stand their ground against the competition. There was sufficient potential to achieve this.

Prior to and during the First World War, the development of four-stroke engines with higher revolutions had been pushed as propulsion for submarines. In 1917, MAN Augsburg built a ten-cylinder four-stroke engine with an output of 3,000 hp (2200 kW) at 390 1/min. Efficiency at the time was approximately 35%.

After the war, the existing submarine engines were equipped with gearing and installed on merchant ships. The first big German passenger ships with diesel engines – the sister ships *Monte Sarmiento* and *Monte Olivia*, built by Blohm+Voss in 1924/25 – were likewise equipped with four medium-speed submarine engines of 1,500 hp each. Their rotational speed of 215 1/min was lowered to 77 1/min by means of reduction gearing. With a tonnage of 13,625 gross tonnes, they were the biggest engine-driven passenger ships

in the world. The advantages of this kind of propulsion soon became obvious, so medium-speed diesel engines with appropriate gearing were built for new passenger ships. But steam turbines with a similar engine layout combined with gearing soon presented fierce competition to the diesel engine.
Both of the express steamers *Europa* and *Bremen*, built for the German shipping company Norddeutsche Lloyd in 1930 and 1928 by Blohm+Voss and AG Weser, respectively, had four geared turbine units with a total output of 100,000 hp (75,000 kW), each operating one propeller. In 1929, the *Bremen* won the unofficial Blue Riband prize for the fastest Atlantic crossing by a passenger liner. Both ships had a capacity of about 50,000 gross tonnes and an average speed of 26.5 knots. To match such speed and thereby maintain competitiveness, the diesel engine needed to considerably boost its output first and foremost.

The turbo-supercharger – a milestone

At this juncture another epoch-making invention came into play that would pave the way for the triumphant advance of the diesel engine as ship propulsion: the exhaust-gas turbo-supercharger. Diesel had mentioned supercharging in his patent and carried out tests on it as early as 1896. Output could be increased by 30%, but fuel consumption was higher. Since Diesel's objective was a high degree of efficiency, he discontinued the tests. A quarter of a century later, the Swiss engineer Dr Alfred Büchi made use of the kinetic and thermal energy of diesel exhaust in a turbine to charge the cylinders with air and thus with oxygen. In 1923 the German shipyard Vulkan in Stettin (today Szczecin, Poland) obtained the commission for two big passenger ships for service with East Prussia, the *Preussen* and the *Hansestadt Danzig*. Both were fitted with two ten-cylinder, four-stroke engines – licensed by MAN – the first successfully supercharged, commercially used diesel engines. Thanks to the supercharging, the engines' output could be increased to a previously unequalled order of magnitude, from 1,750 to 2,500 hp. Turbo-supercharger inventor Büchi was clearly ahead of his time. In 1929, MAN took out a licence and was able to increase output by 136% via a 28% supercharge and simultaneously decrease fuel consumption. Introduced by all major suppliers in 1930, supercharging helped the diesel engine make important headway as a type of ship propulsion.

Final triumph of the diesel engine?

Though the share of diesel-driven ships steadily increased, steam propulsion still dominated because diesel engines were often less economical despite being more efficient. Apart from the investment costs, which were between 10 and 15% higher, the increasing fuel price had a negative effect on the diesel engine.
Global annual oil production had increased tenfold since the end of the 19th century. Gasoil had been considered the most appro-

The *Hamburg Express* – built in 1984 – one of the world's largest container ships, powered by 95,000 hp

priate fuel for diesel engines until the first marine application of the diesel engine. This was a commonly used term in the oil industry for standard diesel fuel, produced at the time by the refinement process of atmospheric distillation. The thick residue occurring in this process, which made up about 40 to 50% of the original amount of crude oil, was burnt as cheap heavy oil in boiler plants. So this was not a major advantage over oil-burning steam propulsion, which partially compensated for the higher efficiency of diesel engines.

Due to rising demand for high-quality diesel fuel, the price differential between heating oil and diesel oil had shifted so unfavourably by 1930 that routes formerly operated economically with diesel-engine ships – despite the ships' higher efficiency and cargo load, less crew and need to bunker – became cheaper when ships with oil-burning, steam-powered engines were used.

Furthermore, diesel engine applications in a power output range higher than 20,000 hp were considered inadvisable in the early 1930s due to the high levels of vibration and noise. The technically feasible maximum output at the time was said to be 30,000 to 40,000 hp because

An MAN diesel engine with turbocharger

cylinder diameters that were too large entailed thermal problems and, in the case of very long engines, their storage in an elastic casing was problematic. Steam turbines were preferred in such cases. So it is hardly surprising that, according to statistics from the year 1935, the share of diesel engines in actively operating marine tonnage was about 11 million gross register tonnes, compared with 52 million for steam-driven engines. Very clear trends were evident, however: Diesel engines were increasing and piston steam engines declined.

Before the outbreak of the Second World War, which rendered further development of the diesel engine in Germany impossible, the situation can be summarised as follows:

After the maiden voyage of the *Selandia* in 1912, the diesel engine was continuously developed further for ship propulsion. Construction costs were dramatically reduced. Prior to the First World War, motor vessels were 40% more expensive than a steamer, a figure that dropped to 10 to 15% by 1930. Furthermore, their operation was substantially improved by means of direct fuel injection. There was a shift from four-stroke engines to single-acting and double-acting two-stroke engines as well as the introduction of supercharging as an essential measure to increase output.

In addition, technically sophisticated diesel-electric propulsion concepts, particularly for the implementation of higher outputs, became available.

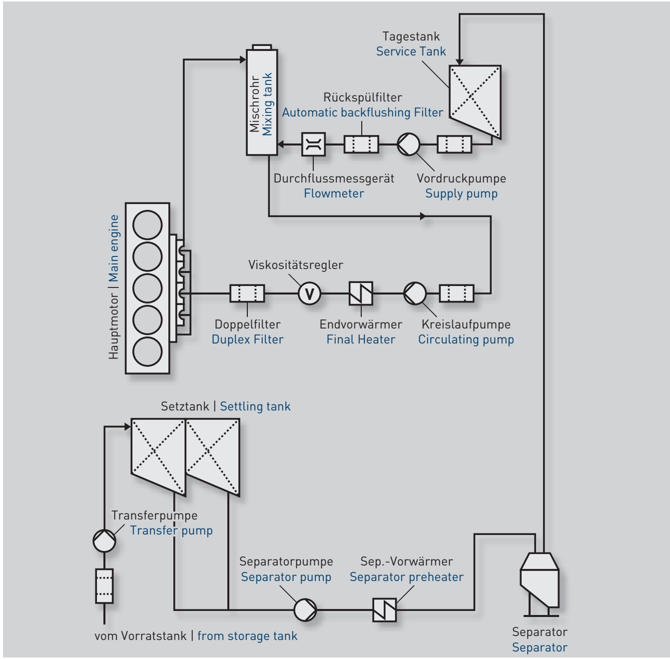
All in all, a lot had been achieved, and the path to future leadership in the world market appeared clear. Nonetheless, satisfactory solutions for two problems were still not in sight: the exclusive use of expensive diesel fuel and the safe implementation of large outputs causing little vibration.

During the Second World War, the diesel oil became scarce, which initially caused construction orders for ships with diesel engines to remain unfulfilled. This put a sudden stop, especially in Germany, to the transition from steamers to modern motor vessels that had begun in the period between the world wars. The fuel shortage made the industry take a step backwards.

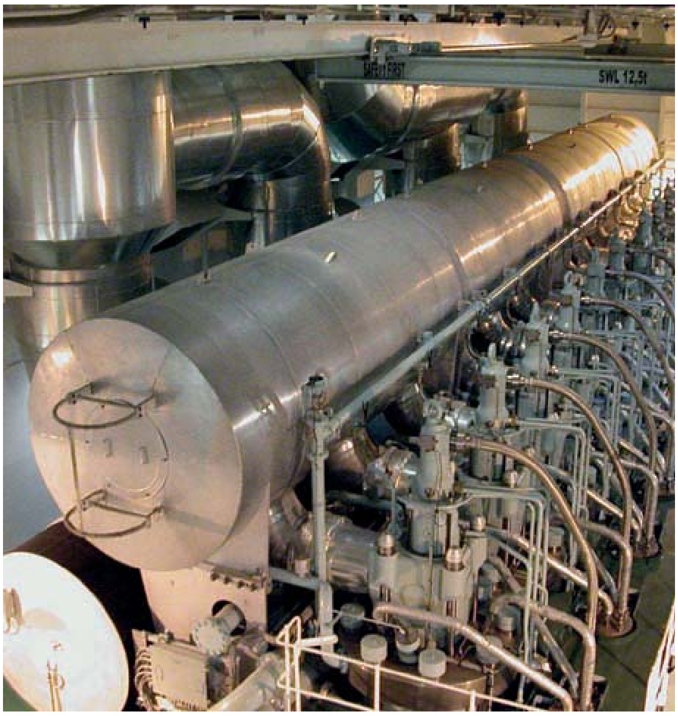
The German shipbuilding programme "Hansa" saw the development of three types of ships – of 2,000, 2,800 and 5,300 gross tonnes – all driven by coal-fired steam engines. More than 200 ships were built under the programme, most of them abroad. The first German newbuilding after the war, the *Brook*, commissioned in February 1950, was also a steamer.

The success story goes on

Despite some setbacks, the diesel engine for ship propulsion became more and more popular in the post-war years. Further development of the engine had continued even during the war and was strongly intensified immediately afterwards. At the annual meeting of the German Society for Maritime Technology (STG) in 1951, a presentation titled "Development of Big Diesel Engines in Germany after the War" described the essential progress that had contributed to an increase of efficiency and reliability. The speaker reported not only on the many and varied improvements and new developments regarding individual engine parts and supercharging, but also on the "installation of engines for the processing of heavy oil". The post-war period was indeed strongly characterised by intensive work on the use of heavy residual oils in ship diesel engines. At issue was overcoming the final important disadvantage of the diesel engine compared with steam propulsion:



Burning heavy fuel in ship engines requires a demanding preparation of the fuel



The MAN B&W 12K 98 MEC

the much higher cost of diesel fuel. As early as 1912, a participant of that memorable STG meeting had expressed that visionary demand: "Gentlemen! In my opinion, in the scenario of ship propulsion, we must and will use in the future only those residues – apart from a few negligible exceptions – that remain after the distillation process of crude oil, such residues that have so far been fired under the boiler." It took four decades until the first promising steps were taken in this direction. A remark by a participant of the STG meeting vividly conveyed the many problems and doubts that had to be overcome: "If anyone told me that an engine driven with heavy oil stayed completely clean after a long operation time, I would take the liberty not to believe it."

In the 1950s, two-stroke engines able to combust heavy oils consisting mainly of residues were developed.

The combustion of heavy oils in diesel engines not only required changes in engine design. Since heavy oils are extremely thick and contain water as well as solid matter, a sophisticated fuel processing system had to be developed, too. Such a system is installed in ships even today.

With this development, the diesel engine finally became the prevailing mode of ship propulsion, and the share of heavy-oil-compatible, two-stroke engines was 80%.

Countless design improvements would follow in the years to come, – not only to two-stroke but also four-stroke engines, which became able to combust heavy oil as well. Improvements included the use of high-tensile and heat-resistant materials, better and better processing and foundry practices, high-pressure fuel injection and intelligent supercharging systems, to name just a few. All these developments were aimed at increasing the efficiency, reliability and the output of the diesel engine.

Pressures and temperatures that could be implemented and mastered became higher and higher. In the 1950s, the mean working pressure of a supercharged four-stroke diesel engine was between 12 and 14 bar, rising to 18 bar in the 1980s, 23 bar in the 1990s and up to 27 bar today. In the same period, ignition pressures increased from 80 bar to more than 200.

Modern engines additionally benefit from another stage of development that came with the introduction of electronic control of key functions, particularly of fuel injection. The idea of electronic injection is even much older. As early as 1979, common rail injection technology was tested in a slow-speed, two-stroke engine at MAN in Augsburg, just one possible kind of electronically controlled injection. But this technology failed due to the sea-shipping industry's scepticism at that time towards any electronics in engine rooms.

It took another 20 years until the first engines with common rail systems were brought to market maturity. But then the development was unstoppable: In a period of only six years, between 2001 and 2006, all major diesel engine manufacturers launched such electronically controlled engine types. The development of two-stroke and four-stroke engines ran almost parallel.

Electronic control of essential parameters, such as fuel injection and the control of exhaust valves, allowed for an optimisation of all engine load ranges, opening up completely new opportunities to further reduce emission levels and fuel consumption.

The LNG carrier is powered by dual-fuel engines

Status quo and prospects

In recent decades, exhaust gas emissions of ships with diesel engine propulsion have attracted increasing public attention. The main demand was for a significant reduction of shipping-related emissions. Consequently, the International Maritime Organization (IMO) as well as national regulators set emission limits. Long characterised mainly by efforts to cut fuel consumption, ship engine development now had an added objective: keeping the concentrations of pollutants in exhaust gases low.

So engine manufacturers began devising intra-engine measures aimed simultaneously at both high efficiency and reduced emissions including low soot concentrations and – if possible – no exhaust plume.

Current IMO regulations on pollution limits for the international shipping industry, which dominate ongoing R&D activities, are contained in the International Convention for the Prevention of Pollution from Ships, known as MARPOL 73/78.

On September 27th 1997, MARPOL 73/78 was amended by Annex VI (Regulations for the Prevention of Air Pollution from Ships), which sets limits on nitrogen oxide (NOx) and sulphur oxide (SOx) emissions from ship exhausts and prohibits deliberate emissions of ozone-depleting substances.

IMO emission standards are commonly referred to as Tier I, II and III. Tier I standards were introduced in the original version of Annex VI, while Tier II/III standards were defined in the revised Annex VI, adopted in 2008.

Annex VI comprises two sets of emission and fuel quality requirements:

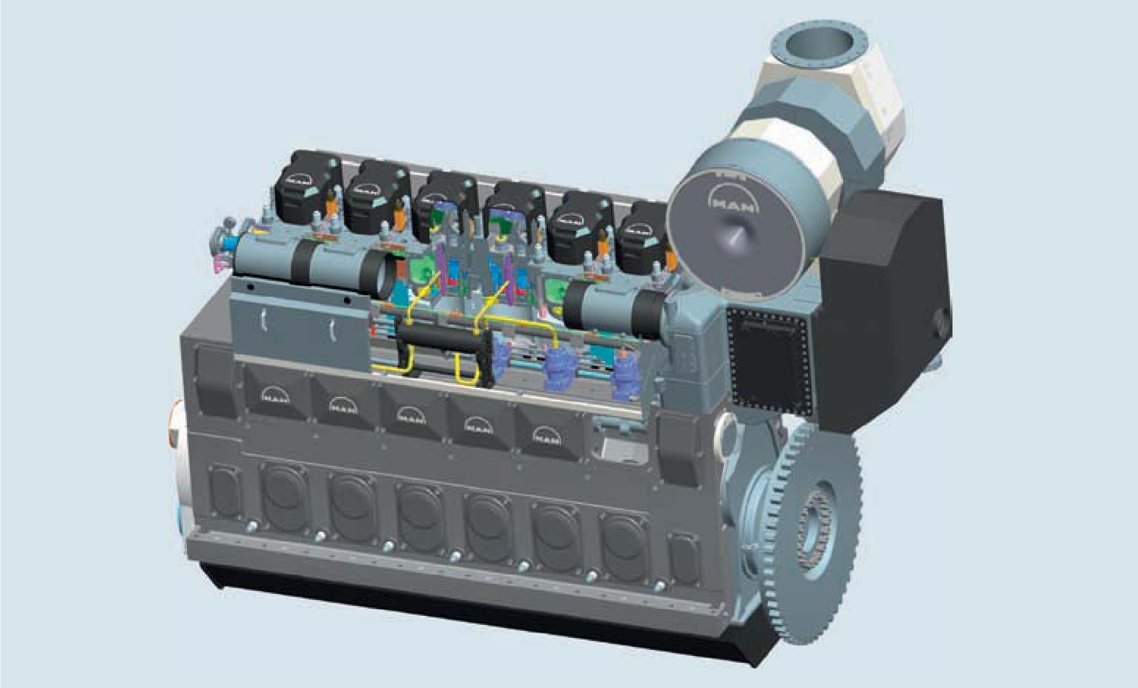
- global requirements and
- more stringent requirements for ships in Emission Control Areas (ECAs).

NOx emission limits are set for diesel engines depending on the engine's maximum operating speed (n, rpm); Tier I and Tier II limits are global, while Tier III applies only in NOx ECAs.

Tier II requirements have been met by all leading diesel manufacturers, so today's diesel engines not only comply with the pertinent NOx limits but in some cases even go beyond them.

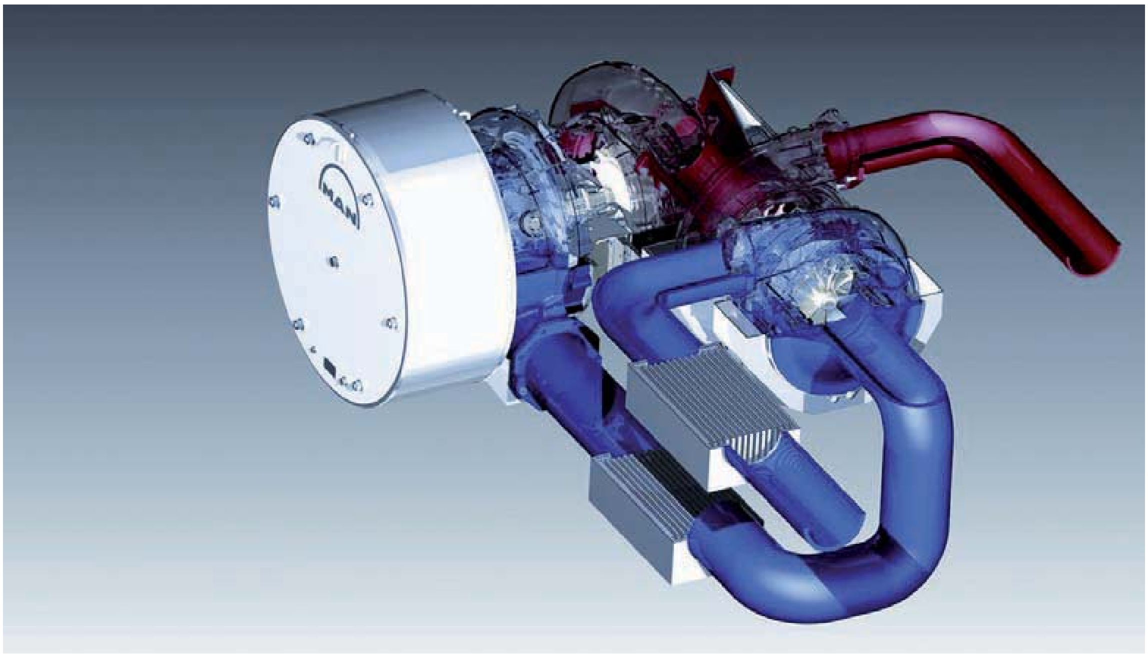
In addition, amendments to MARPOL Annex VI in 2011 added mandatory measures to reduce emissions of greenhouse gases (GHG). The amendments came in a new Chapter 4: Regulations on Energy Efficiency for Ships.

Driven by these environmental regulations and growing sensitivity to ecological impacts, the entire maritime industry is now trending towards greener systems with simultaneous improvements in efficiency.



A model of MAN's 32/44 CR engine, showing the common rail system

Development of new or alternative, environmentally friendly propulsion technologies and suitable exhaust gas treatment concepts is therefore gaining in significance.
This is especially important with respect to IMO Tier III limits, which enter into force in 2016 in ECAs. They require a reduction in NOx emissions of approximately 80% compared with current levels. Particularly in view of new regulations on fuel sulphur content along with SOx emission limits of 0.1% in ECAs beginning in 2015, new technological approaches are needed for marine diesel engine plants. Technical



Two-stage turbocharging with intermediate cooler (simplified illustration)

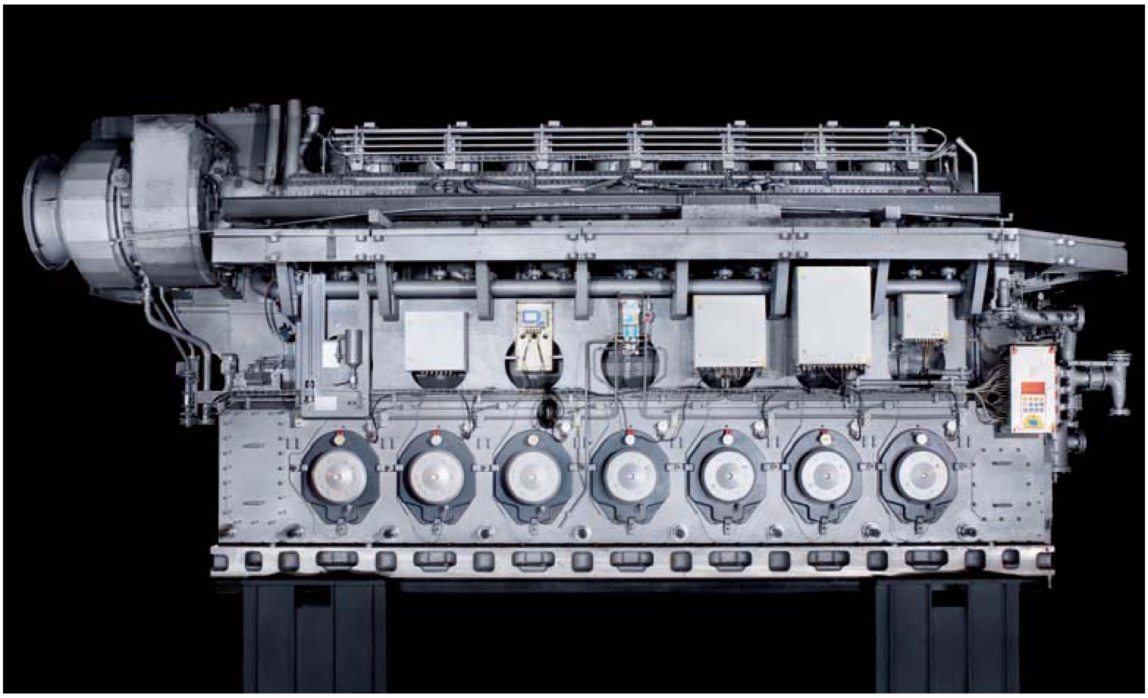
solutions based on exhaust gas treatment such as sulphur scrubbers as well as the usage of LNG or exhaust gas recirculation concepts are currently being discussed or developed.

More than 98% of the ships worldwide with over 2,000 TDW are powered by diesel engines today. Slow-speed two-stroke engines as the main propulsion account for 75% of the total installed output. The diesel engine, with efficiency as high as 52%, is the most economical mode of ship propulsion.

The biggest diesel engines currently installed in ships are 14-cylinder, two-stroke engines whose output of 80,080 kW, or 108,000 hp, is about 6,000 times higher than that of the first diesel engine of 1897.

The recent developments described above impressively show that the diesel engine still has considerable potential; the limits of design development are far from foreseeable. The use of LNG in dual-fuel engines, in particular, is expected to play an increasingly important role in the industry. With regard to the upcoming IMO regulations – above all the global target of a 0.5% cap on SOx emissions from 2020 on – the days of heavy fuel oil, once so very important in shipping, could be numbered.

Diesel engine makers are preparing intelligent solutions for these challenges. It will still take quite some time before alternative kinds of ship propulsion have been sufficiently developed to offer an economically viable alternative to diesel engines.



MAN Diesel & Turbo's dual-fuel engine 51/60DF, which can utilise gas as well as conventional liquid fuels

"We are completely ready for LNG as a fuel"

MAN Diesel & Turbo has a long and moving history in the development of diesel engines for the shipping industry. Thomas Knudsen, head of Low Speed, points out some of the main aspects of recent and current engine manufacturing.

Thomas Knudsen, head of Low Speed, MAN Diesel & Turbo

Mr Knudsen, your namesake, Mr Ivar Knudsen, who was director of Burmeister & Wain at the time when the *Selandia* was being built, was one of the first engineers in the 19th century who pointed out that Rudolf Diesel's technical ideas were especially noteworthy. What do you think were the most significant milestones in the development of the diesel engine over the last century?
I would say that since the introduction of the very first engine, the design and efficiency have been continuously developed and improved. Today it is safe to say there are no limits to how large a diesel engine can be, nor to how great a power output a diesel engine can have. If I had to mention particular milestones, I would nominate the introduction of turbochargers and, more recently, electronically controlled engines.

What substantial input did MAN contribute to this development?
I am happy to say that MAN was the first company to introduce an oceangoing, diesel-driven ship with

The Danish headquarter of MAN Diesel & Turbo SE

turbochargers, and we were also the first to develop and introduce an electronically controlled engine for the propulsion of ships via our ME portfolio.

How would you describe the current status of engine manufacturing?
The current situation, indeed the situation as it has been for a number of years now, is that shipbuilding is now concentrated in Asia instead of Europe. As a natural consequence, most low-speed engine manufacturing also takes place in Asia, adjacent to the ships, on account of the engine sizes.

What are the key components of your R&D activities to meet future demands – especially with regard to upcoming emission limits?
We are currently working on a broad range of initiatives, primarily in the area of reducing emissions. To meet the coming Tier III legislation, we are following two main lines: one being SCR, and the other EGR. Both system concepts are capable of meeting Tier III limits, and we are working hard on making cost-effective, reliable systems.

MAN recently announced the first order for its second-generation exhaust gas recirculation (EGR) system, which will enable compliance with

First order for Tier-III EGR system

Maersk Line | MAN Diesel & Turbo has announced the first order for its second-generation EGR system, to be applied on board a Maersk Line container vessel – the 4,500-TEU newbuilding #2358. The system will be fully integrated with the vessel's main engine, a two-stroke MAN B&W 6S80ME-C9 type to be built by Hyundai Heavy Industries' engine and machinery division.

The EGR system is said to enable compliance of the imminent IMO NOx Tier III emission levels, due to come into force on January 1st 2016.

The newbuilding #2358 from Hyundai's shipbuilding division is in the C-class series of 22 container vessels ordered by Maersk Line and will be delivered in early 2013.

Graphic of the second-generation EGR system (orange) integrated in its host engine

Upon delivery, the vessel will serve the trade route between East Africa and the Far East. For a test period of three years, the engine will be operated partly at IMO Tier III NOx emission levels.

The newly developed ME-GI two-stroke gas engine was presented during a customer event in Copenhagen in 2011

the imminent IMO NOx Tier III emissions level. Could you briefly describe the technical details of this particular unit?
We have had an EGR system on the test bed and subsequently tested it aboard a ship, and we are now happy that Maersk Line has ordered such an EGR system – our new integrated version. This is obviously a very important order for us because it means that we will now gain valuable operational experience. Additionally, it's an integrated solution, meaning that it is easier for the shipyard to install aboard the ship. The EGR principle is well known from the automotive world. Basically, we decrease the combustion temperature by removing some oxygen from the combustion chamber, and this lower temperature reduces the amount of NOx produced. This is achieved by recirculating part of the exhaust gas, which, because we are talking about HFO-burning engines, also includes a scrubber in the recirculation loop.

The use of LNG (liquefied natural gas) is widely seen in the maritime industry as a major way to reduce emissions and comply with current and future environmental legislation. What do you consider the greatest challenges and opportunities of using LNG as a ship fuel?
We are completely ready for LNG as a fuel. The greatest challenge, as we see it, is bunkering possibilities for oceangoing ships.

Will dual-fuel engines be the main solution to temporary infrastructure shortages for the use of LNG as marine fuel?
If you look back to when the diesel engine was first introduced, it took a number of decades before it established itself as the dominant propulsion type owing to the time it took to establish bunkering possibilities globally. In fact, for its first few decades, only liners utilised diesel engines, and later tramps. If we look at the current situation with LNG, I think a similar pattern may emerge where dual-fuel vessels predominate for a transitional period of time – how long, I don't know – until LNG bunkering facilities are firmly established as a global network. The rate at which LNG bunkers are established will depend in great part on LNG's pricing versus HFO. Even though the infrastructure is not yet in place, an engine can be ordered as "LNG-ready".

Can you describe your company's strategy with respect to scrubber technologies as a way to meet SOx emission limits?
This is a very interesting technology and we have entered into cooperation agreements with companies that are specialised in scrubber technology. In connection with the development of EGR, we have developed our own integrated scrubber unit, which takes care of the small amount of recirculated air.

What do you think will have the biggest influence on the development of engines in the next ten years, and what will result from these influences?
Clearly, it will be the introduction of local and international environmental legislation governing pollution levels. The result will be engines that are even more environmentally friendly: clean exhaust with unprecedented high efficiency.

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